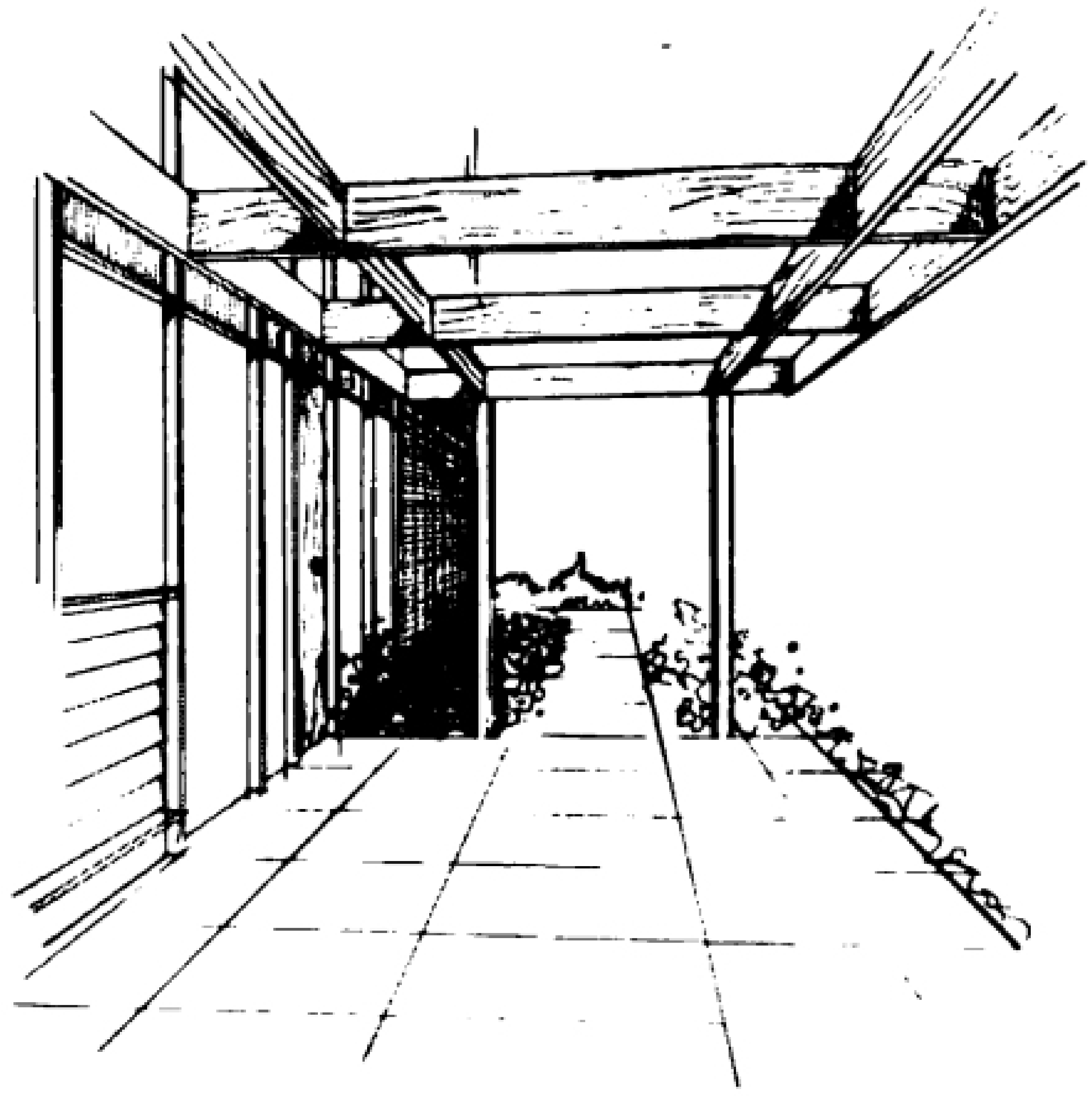
NAHB • MSU RESEARCH HOUSE

developed by NAHB RESEARCH INSTITUTE • MICHIGAN STATE UNIVERSITY

NATIONAL ASSOCIATION OF HOME BUILDERS



NAHB • MSU RESEARCH HOUSE

East Lansing, Michigan 1959

DEVELOPED BY

NAHB—RESEARCH INSTITUTE *and*
MICHIGAN STATE UNIVERSITY
Residential Building Curriculum

A SUMMARY REPORT

NATIONAL ASSOCIATION OF HOME BUILDERS RESEARCH INSTITUTE

ROBERT F. SCHMITT, Chairman
ALAN E. BROCKBANK
GEORGE S. GOODYEAR
DANIEL B. GRADY
RICHARD D. HUDSON
I. P. JACOBS
ANDREW S. PLACE
CLAYTON H. POWELL
HERMAN H. YORK

RALPH J. JOHNSON, Director
JOHN M. KING, Assistant Director
ROBERT C. GARROW, Assistant Director
HERMAN H. YORK, Consulting Architect

FOREWORD

The NAHB Research Institute was founded to assist the home building industry to produce better value homes through research. One of the important methods of attaining this goal is to stimulate the development of new materials, equipment and construction methods that will help builders build a better home for a lower cost. The research house program provides a practical, full-scale means of achieving that goal.

This Research House continues the program initiated by the first Research House in 1957. In this program, the Research Institute develops new ideas and essential performance specifications for new materials and equipment that would improve the quality of the house or lower its cost, or both. These are then presented to progressive manufacturers who are willing to develop such new products. In addition, the Research Institute adapts for house construction, new materials or products developed by manufacturers. In this process, there is blended the knowledge of manufacturers about their materials and production machinery with the knowledge of builders about the homebuilding process.

This house represents another forward step in the maturing of home building from a craft to an industry. Structural sandwich panels, produced under controlled conditions of production and quality, are utilized as components to speed and simplify the construction process. One component part is substituted for ten to twelve site applied layers of materials. The stressed-skin principle utilizes the materials most efficiently and feasibly for use today. This house demonstrated the use of one-story construction methods for a two-story house. It further demonstrated the flexibility of component sandwich panel construction during inclement or cold weather conditions.

There are many significant new developments in this house. I especially urge builders not to overlook the advantage of the fundamental principle utilized in the design of this house: it is designed to be built faster. A shorter construction schedule, of course, has significant cost-saving implications.

I would like to call special attention to the personal contribution of Mr. Robert F. Schmitt, Chairman of the Research Institute and Project Manager of this house. He, along with the other Trustees of the Research Institute, gave unselfishly of their time, talent and money for more than a year to complete this house. I would like also to express my personal appreciation to Michigan State University which co-sponsored this house; to Dr. Alexis Panshin, head of the Department of Forest Products, and to Mr. Byron Radcliffe, Associate Professor, Residential Building Curriculum. The success of this project was made possible through their fine cooperation.

I especially acknowledge the outstanding contribution of the Koppers Company. Their wholehearted cooperation with the Research Institute for more than three years in the research and development of the stressed skin panels contributed greatly to the value of the house. I am also pleased to acknowledge the cooperation of numerous other manufacturers whose names are listed in the appendix and who contributed to the success of this program.

As Immediate Past President of the National Association of Home Builders, I am especially pleased to commend this report to home builders, architects, engineers and manufacturers in the furtherance of our mutual goal in producing a better home for all Americans.

Carl T. Mitnick

CARL T. MITNICK
Immediate Past President
National Association of Home Builders

159

CONTENTS

PREFACE

This house represents the culmination of more than three years of research, development and study by the Research Institute and the cooperating manufacturers. It is an intelligent combination of new ideas, materials and construction methods but is not intended to be a "model" house. This two-story home provides maximum livability and demonstrates the application of one-story methods of construction using two-story component units. The use of these components and many other new ideas and methods made it possible to construct the home during cold and inclement weather which would have precluded using conventional construction.

All of the new items included in this house are applicable to housing in the Lansing, Michigan, area. It is not expected that builders will want or be able to use all of the new items in any one house or in all areas of the country. All of the ideas contained in the house are capable of being adopted individually or in combination depending upon the requirements of local design, climate and market. All of the new items in this house are intended to be used by small or large volume builders.

We particularly acknowledge the cooperation of Michigan State University which provided the land on which the house was built. We also express our appreciation to Dr. Alexis Panshin, head of the Department of Forest Products and to Mr. Byron Radcliffe, Associate Professor, Residential Building Curriculum, and to his students who gave a great deal of their time to this project. We also acknowledge the cooperation of the Home Builders Foundation of Michigan State University. This group of builders, whose purpose it is to foster the Residential Building Curriculum at Michigan State University, helped considerably in the design, planning and administration of the project.

We acknowledge the contribution of Mr. Herman H. York, who acted as consulting architect on the house, and Mr. Walter Neller, who served as contractor for the construction. Mr. Charles Prince and Mr. William Mlejnick of Blue-Ribbon Builders, who were the erecting builders of the house, assisted with the construction of this home. Mr. Phillip J. May, Comptroller of Michigan State University provided valuable assistance by keeping the accounts and handling the disbursement of funds necessary for the completion of this project.

Mr. Robert Jipson of Jipson Brothers Plumbing helped in the design and construction of the plumbing system of this house. Mr. Dempster Alberts of Lansing Electric Company aided in designing the electrical wiring and lighting system. Mr. Ernest Fox of Hager and Fox provided valuable assistance in the design of the heating and cooling system. We are especially grateful to Mr. Emory Caldwell, Chairman of the Michigan State Plumbing Board, who cooperated with the mechanical manufacturers and contractors in the design and construction of the plumbing system.

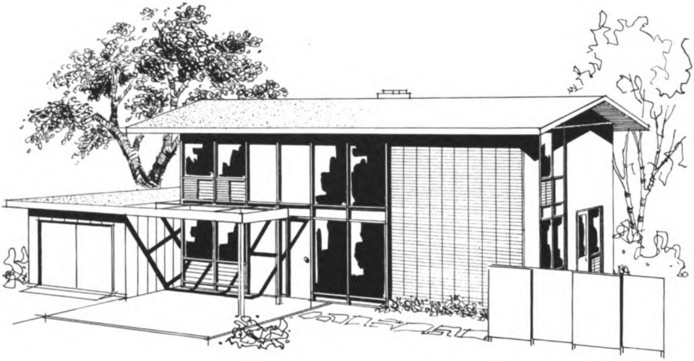
The public evaluation of the house was made possible through the cooperation of the Michigan State University, Residential Building Curriculum, and by "American Builder" Magazine which designed and tabulated the results of the public opinion questionnaire.

Finally, I want to emphasize that this house was a joint effort of all the Trustees of the Research Institute. They have contributed numerous ideas and given freely of their time and money in many long and tedious sessions during the past year. I also want to acknowledge the outstanding contribution of Ralph J. Johnson and Robert C. Garrow of the Research Institute staff. They provided important assistance with the planning and design of the home and contributed many of the ideas incorporated in the house.

Of course, the project could not have been successfully completed without the wholehearted cooperation of the many progressive manufacturers who expended substantial amounts of time and money to develop new materials and equipment. The names of these manufacturers are contained in a special list in this report.

Robert F. Schmitt

ROBERT F. SCHMITT
Past Chairman, Research Institute



INTRODUCTION

The fundamental objective of the NAHB Research Institute is to try to assist builders to build a better house at a lower cost in all price ranges. The Research Institute is working to achieve this goal by several methods. One of these is the Research House Program.

The Michigan State Research House was intended to achieve the following basic objectives:

1) The design and development of progressive construction methods;
2) The development of performance specifications for new materials and equipment;
3) The specification of these items to progressive manufacturers, thereby tending to accelerate the rate of development of products designed especially for the home building industry;
4) To obtain field test data on the performance of new construction methods and materials;
5) To obtain certain comfort, liveability and operating data on the occupied houses by instrumentation and planned questioning of the family selected to occupy the house, and to get builder and public reaction to the new and untried products.

This house was intended to show the results of research progress accomplished since the 1958 research houses; to demonstrate the ability to construct a two-story house using one-story construction methods with components; and to demonstrate the flexibility of such component systems for construction during inclement weather.

We would like to emphasize that no attempt was made to create a model or show house—rather, we did attempt to put the new components together into a good, liveable house suitable for today's market and, of course, designed especially for the Lansing area. This method of procedure makes it possible for builders to adopt immediately any or all of the items included in the house as they become available and as they are appropriate to that builder's current operation, market and climate. Some of the items, of course, are not yet available but will be as soon as research information so indicates and development and manufacturing schedules permit.

A few simple ground rules were established for the design and development of this house. It was intended that the house should represent evolutionary rather than revolutionary progress—an advance of two to five years, not fifteen to twenty Therefore, the new experiments in this house are expected to have immediate practical value. All of the new materials and equipment were developed, specified or selected either to help solve a construction problem or because it was expected that they would give better performance for a lower cost, either currently or when in mass production.

The house is co-sponsored by the NAHB Research Institute and Michigan State University, Residential Building Curriculum of the Department of Forest Products. The Research Institute provided grants-in-aid to the university for some of the costs incurred. Most of the manufacturers who cooperated in this program supplied some of the material free and in the case of experimental products are warranting to the builder the performance of these products. Of course, much of the materials and equipment are standard and were purchased. Manufacturers made no direct cash contributions to the project but did, of course, spend considerable sums in the development of new products.

The house will continue to be owned by Michigan State University and rented. The tenants of the house will agree, in return for certain benefits, to supply certain information and operating data; to allow the right of entry for observation and testing purposes and to report their operating experience with the house.

DESIGN

This house is of a contemporary two-story design. The back wall serves as a retaining wall with the rear bedrooms at ground level. The house contains two thousand square feet of living area with an attached

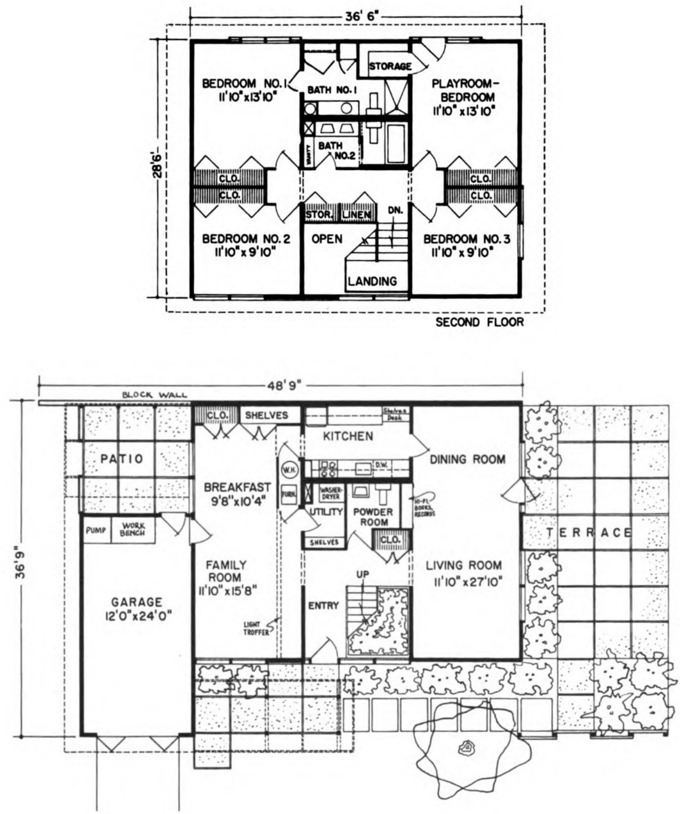


FIGURE 1 — *Floor plan of NAHB—MSU Research House*

one-car garage, service patio, covered entry walk and living terrace (see figure 1). A play deck will be added at the rear of the house.

The first floor on-grade contains the living area. The kitchen is a corridor design and is located at the rear of the center bay opening into both the dining and breakfast areas. The upstairs comprises the sleeping area, with a large master bedroom and private bathroom at the rear. Another large bedroom of equal size serves as a possible playroom and it includes a storage closet in addition to the wardrobe. The two front bedrooms are smaller but are well lighted and spacious. The hall bathroom is exceptionally large with a double bowl vanitory and is compartmented by a sliding door.

Large 8′ wardrobes in each bedroom with an additional wardrobe in the master bathroom afford excellent clothes storage. A storage and wardrobe closet at the rear of the breakfast room affords clothes storage in addition to the entry closet on the first floor. An upstairs linen and broom storage closet is provided by a large free-standing unit in the hall. The utility room contains additional linen and broom storage. A record and book shelf area is located in the living room alcove utilized by the built-in hi-fi unit. The 12′ x 24′ garage affords additional storage and shop facilities.

The house contains a large amount of glass area, equal to 21% of the floor area, all of which is fixed glass providing excellent view and natural light. Cathedral ceilings in the upstairs bedroom give an appearance of greater space in these rooms. The inside kitchen, baths and powder room have excellent light provided by luminous ceilings.

BUILDING CODES

The house was built on Michigan State University land which is not subjected to code requirements other than that of the Michigan State University Architect. Considerable cooperation, however, was obtained from the Michigan State Plumbing Board since a considerable number of progressive plumbing materials were used, such as plastic pipe and fiberglas lavatories and showers.

Of course, the health, safety and welfare of the occupants were of prime consideration. Good health and safety principals and liveability standards were maintained in the design of the house.

EXPERIMENTAL PRODUCTS AND EQUIPMENT

This research house contains numerous experimental products. Only a few of these are available today. Some are expected to be available late in 1960, and a few may not be available for several years. Builders interested in products used in this research house should contact the manufacturers for dates when available and probable prices. As stated previously, almost all of the products or methods used in the house are aimed at better performance and lower cost. Pricing of experimental products is difficult and in part depends on the volume of production and sales. Therefore, the actual price of many products used in the house is not immediately available but estimates of probable pricing were developed before products were selected.

STRUCTURAL DESIGN AND PANELS

All wall, partition, roof and slab floor panels were manufactured by Koppers Company. These panels are Dylite foamed core sandwich construction, and the core material is a foamed in-place polystyrene with a density of 1 lb./cu. ft. Skin materials are bonded to the core by heat activated adhesive, and the foamed core provides an excellent insulation and is a moisture vapor barrier. In addition to the insulation value and vapor barrier, the foam core imparts structural stability to the skin materials. The skins in effect become structural or stressed skins and are resisted in buckling by the bonded foam core.

The design loads for the house are as follows:

Roof load — 40# live load — 6# dead load
Second floor loads—30# live load 8# dead load
Lateral wind load—20#/sq. ft.
Retaining wall lateral pressure — 1,000#/lineal ft.
Uplift design load—12#/sq. ft.

The roof and floor loads are transmitted to the four lateral bearing walls (see figure 2). The retaining wall is designed as a simple beam spanning between the sill plate and the second floor (see figure 3). This load is transmitted to the sill and to the second floor which acts as a diaphragm which in turn transmits the load to the lateral walls. These walls act as buttresses by racking resistance and transmit the loads to their sill plates. Connection at joints between all panels is by means of 2″ wood splines which are nailed 8″ on center along the edge of each panel. The outside skin of the exterior wall panels overlaps the sill plate and is nailed 8″ on center to the plate. Aluminum hold-down straps on the inner face of the wall panels are nailed firmly to the plates and to the wall panels at the joints.

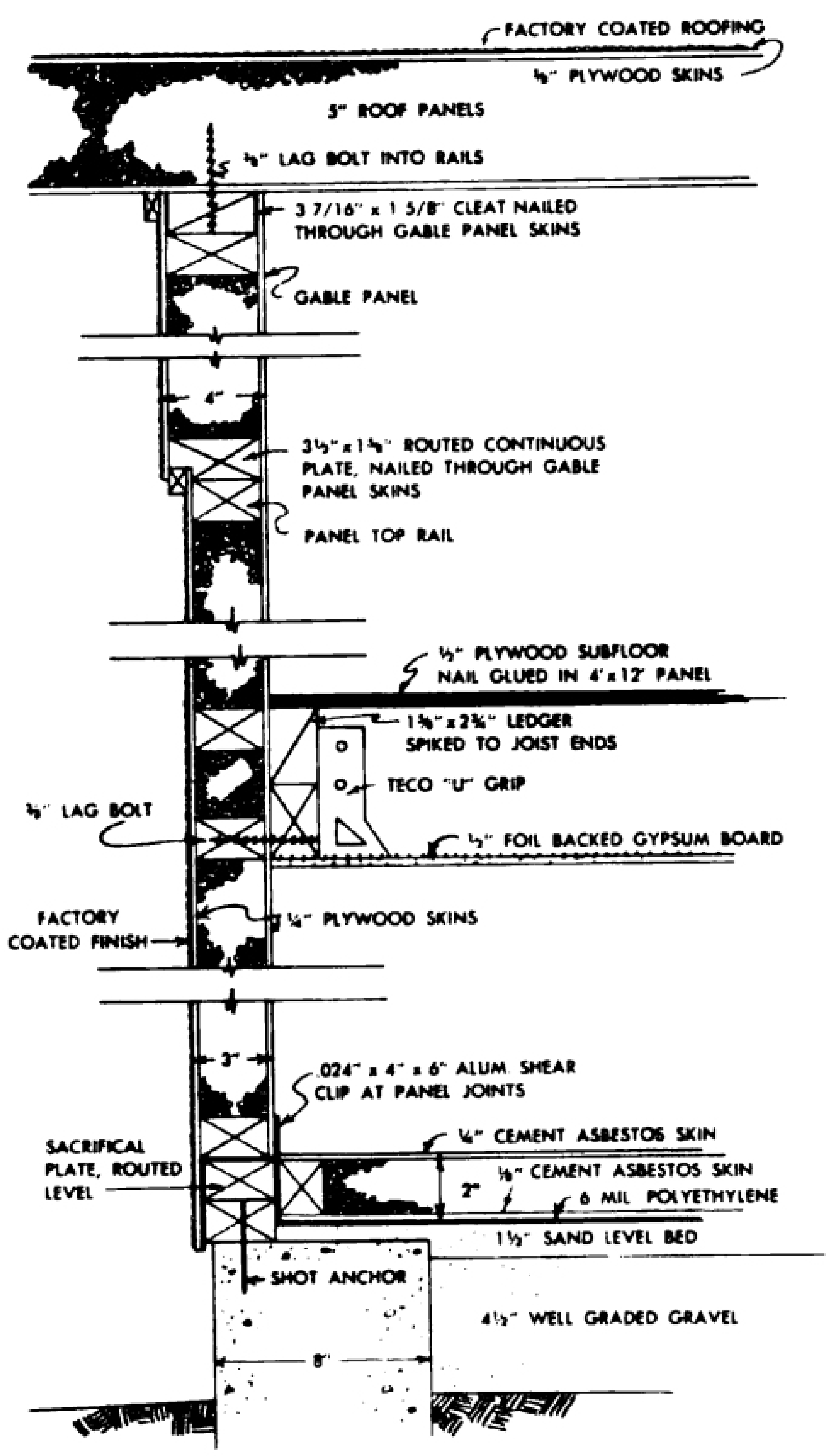


FIGURE 2 — ***Section through end wall, floor slab, second floor and roof***

All wall and partition panels contain wood members at the top and bottom for use in connections. The exterior wall panels contain imbedded wooden members at the second floor height for connection of the floor panels. The plywood skin exterior wall panels and roof panels have a 2½ mil. aluminum foil bonded to the exposed faces. This foil is manufactured by Reynolds Metals Company, and is bonded to the plywood with a neoprene adhesive. A clear epoxy prime coat is applied to the exposed surface of the aluminum for bonding of finish and joint materials. The foil was used in the Research House to create as perfect a vapor barrier as possible for the plywood, and, in addition, provides an excellent base for long life finishes. The foil moisture seal was an essential requirement in the use of the plywood panels below grade at the rear of the house.

FOOTINGS AND FOUNDATIONS

The footing was designed on the basis of the bearing capacity of the soil and the load which would be imposed upon it. Soil tests were undertaken by faculty members of Michigan State University and a resultant soil bearing value of 2000#/sq. ft. was established. An 8″ x 32″ grade beam footing was used with 26″ into undisturbed soil. Concrete for the footing grade beam was a standard five sack mix, and one ½″ steel rod was placed at the bottom and at the top of the grade beam.

A double sill plate was used to facilitate a new plate leveling system. On the front

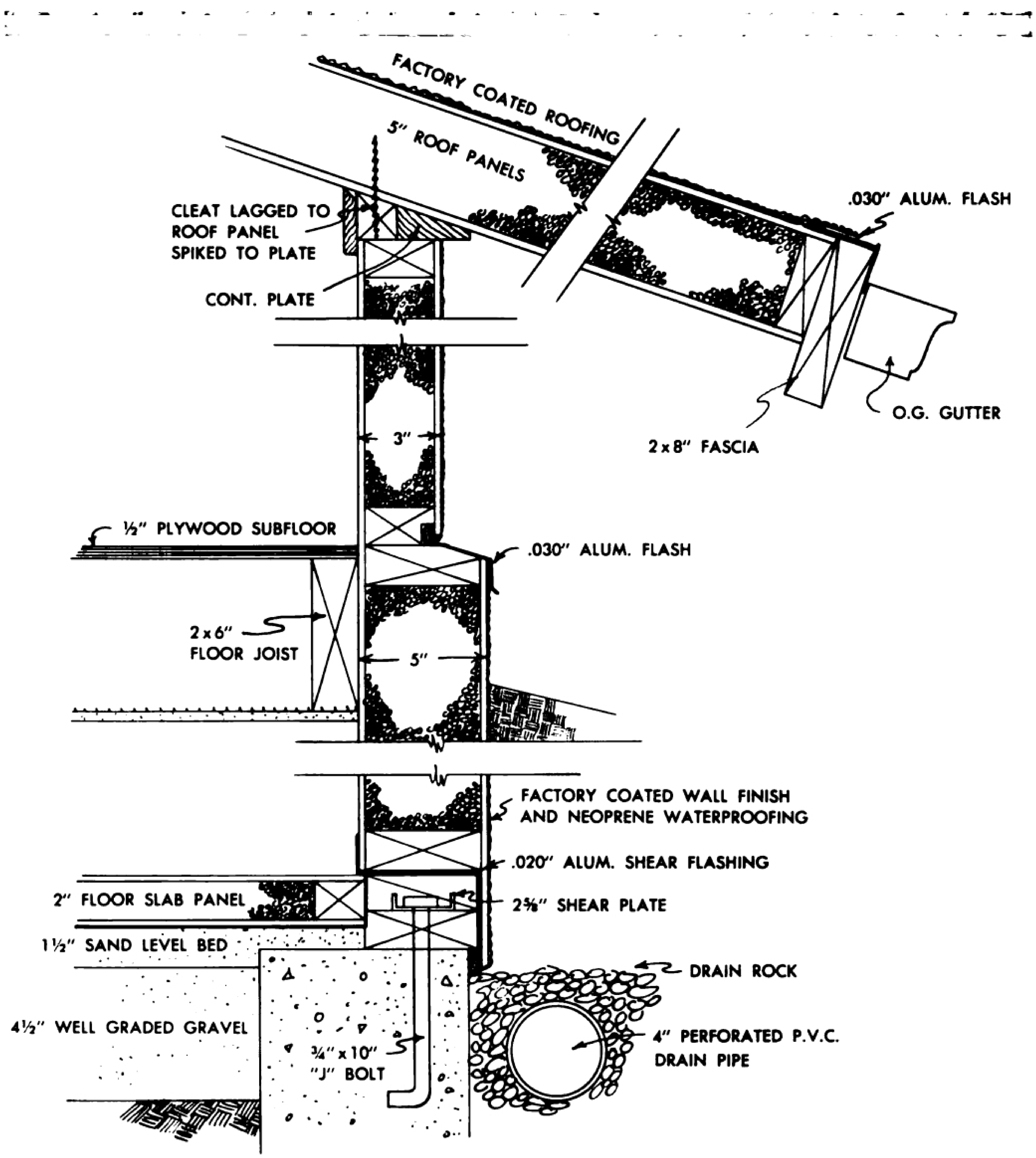


FIGURE 3 — *Section through rear retaining wall, floor slab, second floor and roof*

and side walls as well as the garage walls, a 1⅝" x 2¾" sill plate was used. The interior bearing wall utilized 2 x 4 plates. The first sill was anchored to the grade beam by shot anchors located 36" on center. The second sill plate was then spot nailed with aluminum nails to the first plate. On the rear walls which serve to retain the earth at the rear of the house, a 1⅝" x 4¾" sill plate was bolted to the grade beam with ¾" x 10" anchor bolts, located 36" on center. A 2⅝" TECO shear plate was placed over the bolt on top of the first plate, and was firmly seated into the underside of the top plate. In this manner, shear was fully transferred from the top plate to the bottom. Spot nailing with aluminum nails tied the second plate down completely to the first plate. All plates were treated with Wolman salts for termite and rot protection.

In component wall panel construction,

FIGURE 4 — *Sill plate leveling frame and router*

it is important for the sill plates to be as close to level as possible to eliminate the necessity for shimming. This is particularly important where two-story height panels are used. A special sill leveling device was developed by Stanley Electric Tools specifically for use with component panels such as those adopted for this house (see figure 4). This machine consists of a 4′ rigid leveling frame with clamps which will hold the frame firmly to the top plate. It also contains a leveling device at each end. Prism mirrors with arrow indicators are used so that accurate adjustment to a level position can be accomplished. A standard half horsepower electric router was especially adapted for use with this frame. This router has a cam-shaped guide block bolted to the bottom of the router which fits between the guide bars of the frame to offer positive control and eliminate jumping off of the bars.

The sills were first checked for level with a transit, and the low spot of the entire sill plate system was located. Level marks were then placed at several intervals around the sill plate system ½″ below the low area. A chalk line was then snapped around the entire interior face of the sill plates at these level marks. The sill leveling frame was clamped over the plates at the low spot and leveled to the chalk line. The router was placed on the leveling frame and the depth of cut was set to route the minimum amount at the low spot. The top of the plate was then routed to a level plane. When each portion was completed the frame was moved to the next area, adjusted to level, and routing continued.

This router is capable of cutting up to 7/16″ in depth. If a deeper cut is necessary, a second pass would be required with the router. From experience it was found that an entire house can be leveled by this method in approximately two hours with an experienced operator. The end result is a perfectly level plate system which insures that all wall panels placed thereon will be perfectly plumb without the necessity of shimming.

SLAB CONSTRUCTION AND EDGE INSULATION

After rough grading and backfilling trenches, the sub-base of the slab area was leveled and compacted. Approximately 4½″ of well-graded gravel was placed in the slab area, leveled and mechanically compacted. On top of the gravel base a 1½″ sand leveling bed was placed and compacted. A 6 mil polyethylene membrane was placed over the entire slab area. A thicker membrane was used to reduce moisture under the factory made slab panels.

Over the membrane and sand leveling bed, 2″ thick polystyrene foam core Dylite panels with asbestos cement skins were laid (see figure 5). The top of this slab was flush with the top of the exterior plate system. In the living room bay, both skins were ⅛″ asbestos cement. In the other two bays, a ¼″ asbestos cement top skin was used and the bottom skin was ⅛″. These panels were 4′ wide by approximately 12′ long and contained treated wood rails at the ends. The shear connection between floor panels was pro-

FIGURE 5 — *Installing asbestos cement foam core slab panels*

vided by nailing 8″ on center through the skins into treated wood splines. The entire slab area was laid in approximately two hours and 15 minutes, during extremely inclement and cold weather conditions. Cut-outs were made for pipes and conduits where they project through the slab panels. It is estimated that under the conditions of a repeat operation, the installation time could be reduced 50%.

From the experience gained in this research house it became apparent that a relatively dimensionally stable skin material must be used for these slab panels. A more dimensionally stable asbestos-cement board is manufactured, but was not available at the time. Due to more rapid drying of the top skin, a small amount of cupping was experienced, and it was necessary to use a leveling compound to obtain a perfectly level surface.

Some of the advantages of this slab system are its speed of installation, the ability to use the slab for a working surface immediately after placement, and also the feasibility of this type of slab construction during extremely cold weather. The resultant floor slab is entirely insulated, eliminating the necessity for edge insulation.

STRUCTURAL WALL PANELS

The exterior wall panels are 16′ high and 4′ wide. Interior bearing wall panels are one-story high and ranged from 2′ to 4′ in width. The two end walls and the two interior bearing walls are load bearing and carry both the floor and the roof loads. The front and rear walls are essentially non-load bearing. The lower portion of the rear wall, however, serves as a retaining unit to withstand the lateral earth pressure.

The rear wall panels have ¼″ AC plywood foil faced skins, and are 4′ wide by 16′ and 8′ high (see figure 3). The first floor portion of these panels is 5″ thick overall with 1⅝″ x 4½″ vertical wood rails imbedded at the edges and at the center. The upper portion of the rear wall panels is 3″ thick overall, and the inside skin is continuous for two-stories creating a 2″ water table on the exterior face at the second floor level. At the base of the

panels, an .020″ aluminum flashing is placed over the sill plates, and bent up on the inside face of the panels and nailed for shear support of the interior skin.

The north and south end walls contain full height and one story high panels (see figure 2). These panels are 3″ thick with ¼″ aluminum foil faced skins, and are 4′ in width. The full height panels are manufactured with a single sheet of 16′ plywood on each face.

On the north end of the front wall three 4′ x 16′ panels were installed providing an accent wall of Pan-L-Brick. These panels are typical polystyrene core units with ¼″ asbestos cement skins, and are approximately 3½″ thick. The masonry coating was factory applied over the exterior face of the asbestos cement skin. These panels weighed approximately 8#/sq. ft. The vertical joint connection between panels was accomplished by means of a wooden spline similar to the other exterior wall panels.

The remainder of the front wall comprised windows, fixed glass, entry door, sidelight and color accent panels. The accent panels were standard 3″ thick wall panel sections with foil faced plywood skins. These accent panels were stopped into the structural window frames similar to the fixed glass. There were three full floor height accent panels on the front wall, and two small accent panels located on the north wall in an upstairs window frame.

Four triangular shaped gable end panels were used to conform to the pitch of the roof at the end walls. These panels were typical ¼″ plywood construction with foil faces. They were 14′ long and 4″ thick over-all. The height varied from 2″ at the eave to 3′-6″ at the ridge. A continuous wood top plate was laid on the top of the wall panels which fitted into a recess in the lower edge of the gable end panels and was nailed through the skin faces. A similar recess along the top edge of the gable end panels was provided for receiving cleats connected to the underside of the roof panels. These gable end panels overhang the exterior wall face about 1″, and the inside face of these panels is flush with the wall surface.

Two interior bearing walls running from the front to the rear of the house are located to form three 12′ wide bays. These bearing walls utilized Dylite panel construction similar to the exterior wall. They were 3″ thick over-all with ¼″ exposed AC plywood. These wall panels were one story in height, and the widths varied from 1′ to 4′. A 2½″ x 7½″ continuous structural header was placed in a deep recess at the top of the first story panels. This header served to span the openings in the downstairs and tie the wall panels at the second floor level. The second floor joists rested on the top of the interior bearing walls. Connection at the sill was accomplished by the use of an aluminum clip shaped in the form of a "U". These clips were spiked to the top surface of the sill plate and the vertical legs of the "U" were nailed through the face of the panels into the bottom rail.

A 1″ deep recess was provided along the top edge of the upstairs bearing wall panels to receive the triangular filler panels placed on top. The triangular filler panels were shaped to conform to the roof pitch, and were of the same construction as the bearing walls. These filler panels contained the same recess along the top edge as the gable end panels for connection to the roof panel cleats.

The garage wall panels were similar in construction and section to those of the exterior walls of the house, and were one story in height. These wall panels were 3″ thick with typical ¼″ plywood exposed skins. Connection at the sill and the recess along the top of the panels is similar to the house wall construction.

ROOF PANELS

The roof panels for both the house and the garage were 5″ thick, with ⅜″ foil-faced plywood skins on each surface (see figures 2 & 3). Longitudinal wood rails were placed 24″ o.c. in the panels. The roof panels were placed parallel to the ridge, supported on the two end walls and the two interior bearing walls. The end

bay panels were 4′ wide x 16′ long providing a 3′ 9″ gable overhang. In the center bay the panels were 4′ x 12′ spanning the net distance from center to center of bearing walls. The eave overhang at the front and rear was 2′ 9″. The garage roof panels were 4′ x 14′ and provided a 2′ 9″ overhang on three sides.

Wood cleats, nominally 2 x 2, were attached to the bottom of the roof panels by means of 3/8″ x 4″ lag bolts into the wooden panel rails. These cleats dropped into the recesses provided along the top of the bearing walls and were nailed at 8″ o.c. through the wall skins to provide a tie-down. At the front and back walls, a continuous plate with the top sloped to the roof pitch was spiked to the top of the wall panels. The roof panel cleat is located on the inner face of this plate, and was spiked to it for connection. A 2 x 8 redwood fascia was spiked to the panel edges on all sides of both the house and the garage roof. This fascia served to carry the eave overhang at the corners of the house roof, which require support due to the large overhang.

The polystyrene core in the roof panels was 4¼″ thick, and batt insulation was stuffed into the gap at the ridge so that no possibility of cold air infiltration could occur at that point, thus eliminating the possibility of condensation.

SECOND FLOOR SYSTEM

The second floor was essentially conventional joist and subfloor construction. Two factors, however, differed from the conventional system: (1) factory built panels 4′ x 12′ were manufactured in a mill; (2) the joist spans were extended through the use of nail-gluing. The advantage of the prefabricated floor system is its rapid installation. Preliminary NAHB Laboratory studies indicated that the deflection and bending resistance of nail-glued floor systems would allow longer joist spans than presently permitted.

Joists were 2 x 6 x 12′ construction grade Douglas Fir. The sub-floor was ½″ exterior grade C-D plywood in 4′ x 12′ sheets. Casein glue of Government specification was used for the nail-gluing. These panels were factory fabricated at the mill, using 4 joists at 16″ o.c. The sub-floor was then nail-glued over this frame. On the floor panels abutting the end walls, a 1⅝″ x 2¾″ ledger cleat is spiked to the upper ends of the joists. This ledger cleat rests on the ledger bolted to the end walls (see figure 2).

A 1⅝″ x 2¾″ ledger was lagged to the end walls with 3/8″ x 4″ lag bolts 3′ o.c. into imbedded wood members in the panels. The floor panels were laid into place with the ledger cleats bearing on the ledger at the end wall (see figure 6). The end cleat on the panel was then spiked through the wall into the imbedded wood members. TECO "U" grips were added at all single joists and toe-nail spikes were placed at the double joists into the ledger. The double joists at the panel edges were spiked together so that no differential movement could occur. At the interior bearing walls the joists bear on the wall and butt those of the adjacent panels. A

FIGURE 6 — *Second floor panels at end wall and ledger*

2 x 6 x 24″ gusset served to tie each joist over the wall, and were so placed as to avoid interference with heat ducts.

This floor system was easily handled and rapidly installed. The entire second floor was installed in six man-hours. These panels used ½″ plywood with the face grain parallel to the joists. A certain amount of undesirable deflection was found in the plywood between the joists. This could be eliminated by the use of ⅝″ plywood, or by running the plywood perpendicular to the joists.

WINDOWS AND EXTERIOR DOORS

The windows and doors used in this Research House are all essentially floor to ceiling in height. Fixed glass is used throughout for vision and natural light, and ventilation is accomplished with opaque louvres which also give privacy. The exterior flush doors are steel clad insulated units and the sash doors are wood. The typical construction of the window and door frame units utilizes a standard head, jamb and sill section from a rabbeted 2 x 6. These frames were all 4′ wide, with eight units two stories in height, and four units each used in the first floor and the second floor were one story high (see figures 7 & 8). All frames were prefabricated at the mill, and were assembled by nail-gluing. The frames were entirely

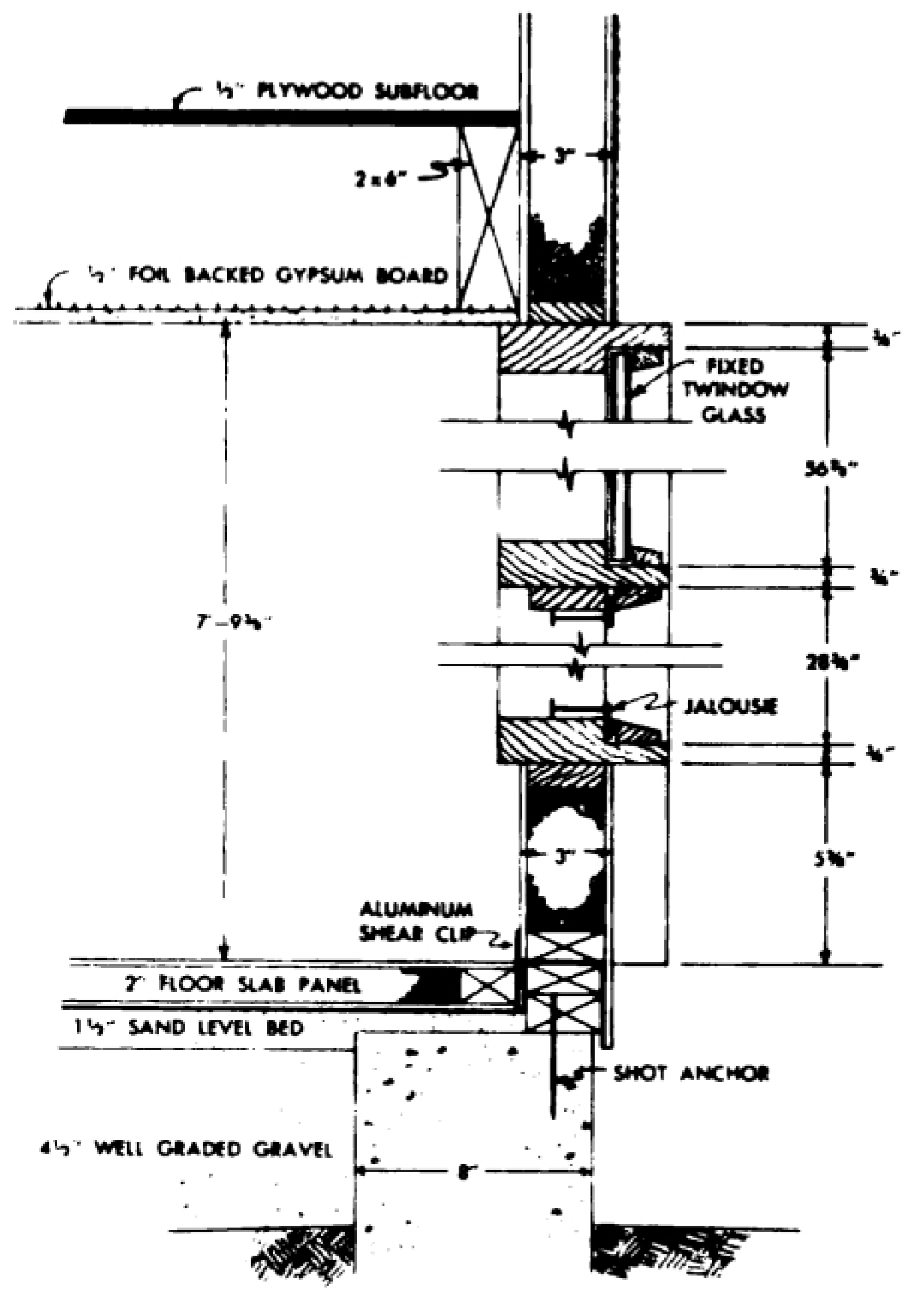


FIGURE 8 — *Vertical section of typical one floor height window units*

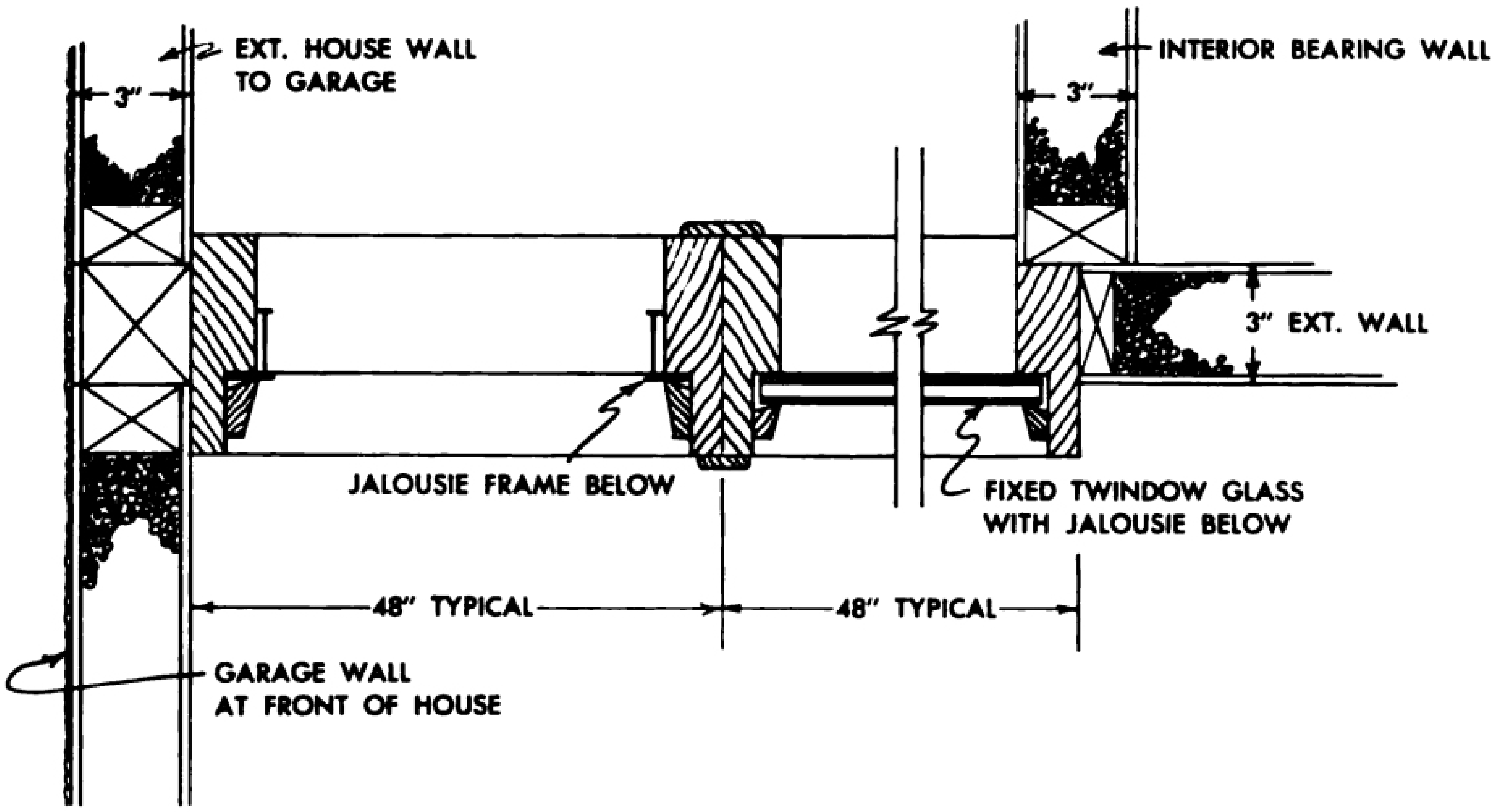


FIGURE 7 — *Plan view of typical window units*

FIGURE 9 — *Typical fixed glass jalousie louver windows*

factory primed and a second coat applied so that only the final finish coat on the job site was required.

Ventilation in the living room, family room and the two front bedrooms was achieved by jalousie operated wood louvres (see figure 9). Ten units 46″ wide x 28″ high are located in the lower ⅓rd of the window frame below the fixed glass. Aluminum jalousie frames and hardware were stopped into the frames at the mill and were installed with the hardware in-place. These jalousies contained two banks of seven louvres each, and the louvre blades, which were field installed, are ¾″ thick rabbetted redwood. The redwood provides better insulation than the typical glass louvre blades. These blades were wrapped in a pre-finished colored aluminum foil. A urethane weather strip seal was used at the rabbet in the blade to provide better resistance to wind infiltration. Experience from this project, however, shows that jalousie ventilation units do allow some infiltration at the vertical edges of the blades. It then became necessary to add storm sash for the cold months which can be replaced with screens during the summer.

On the west elevation, four sidelight ventilating louvre units were used. These louvre ventilating units utilized a fixed wood louvre, 13″ wide x 82″ high, with a screen attached on the inside. These louvres were stopped into the typical wood frame, and double hung panels in a metal track mounted on the inside face of the frame were installed to provide privacy and insulation. These panels were 1″ thick with 1/16″ plywood skins and a low density insulated core. Experience again shows that the reduction of effective ventilation due to the louvres and double hung panels does not allow enough air through such small units. In both the jalousie ventilating unit and the wood louvre ventilating unit the attempt was to separate ventilation and vision.

All fixed glass used in the Research House was Twindow metal edge, manufactured by Pittsburgh Plate Glass Company. The front and side window units utilized ⅝″ clear Twindow with 3/16″ Pennvernon window glass.

The typical window unit contains fixed glass in the upper two thirds area above the jalousie louvre ventilating unit. On the rear or west elevation of the house, full height heat absorbing fixed glass is used. These units are Twindow with 7/32″ Graylite 14 on the exterior, a 5/16″ air space, and 7/32″ Pennvernon glass on the interior. These fixed glass units are 31⅝″ wide x 81⅝″ high. A 17″ x 41″ unit of the same construction was used in the sash door from the playroom to the rear yard. Graylite 14 offers the advantage of reducing heat gain where the orientation of the house produces exposed glass surface to the sun. This glass reduces the glare by 50% and the heat gain by 20%. Although the light transmission is only 14%, the vision from the inside is very good, and daytime privacy is provided since the vision from the outside is restricted.

The sidelight units at the entry door and at the terrace door were foamed core translucent glass sandwich panels manufactured by the Dow Chemical Company. A polystyrene core with large cells and a

FIGURE 10 — *Steel foam core exterior door*

low density creates an attractive, translucent, insulated unit. Sheet glass, ⅛″ thick is placed on each side of the ¾″ core and the entire unit is edged with a plastic tape. The entry panel was 8⅝″ wide x 91″ high, and the terrace unit was 12⅝″ x 91″. Both units were 1″ in total thickness, and were stopped into the frame. Eventually, various patterns and colors may be available. In addition, privacy can be obtained where draping is difficult, and insulation provided where non-standard insulating glass sizes are not available.

The entry door, the door from the family room to the garage, and the door from the garage to the service patio are new foamed core steel doors developed by United States Steel Corporation (see figure 10). These doors are 1¾″ thick 34″ and 36″ wide x 90″ high. The foam core used in these doors is a low density urethane. The faces are 22 gage steel, made in two separate pans and connected at the door edge with a plywood filler and a neoprene weather stripping seal, so that no through conductance of metal occurs. The main entry door was hung in the typical wood frame, and the garage doors were hung in an integral half frame of pre-finished steel, and the exterior portion of the frame was filled out in wood to match the trim. The entry door was primed for field applied accent color to match the exterior colors of the house. The other two doors had vinyl clad steel on the inside face and baked enamel on the exterior face.

The sash door from the playroom to the rear yard was a unique wood unit specially designed for thermal insulating glass. The glass frame was hinged for ventilation, with a screen, and contained a Graylite 14 Twindow glass unit. A special hardware device which automatically closes the sash portion into the door avoids jamming against the wall when the door is opened. The sash door from the dining room to the terrace is a standard flush wood unit with single glazing. The glass size in this door matches the sill of the adjacent window unit. The terrace door has an aluminum storm door.

All exterior doors utilized a new design in lockset knobs. Delrin nylon was used which offers variation in color and potential advantages in durability and wearability. The entry door lock utilized a highly styled white knob which was manufactured by Challenger. The remaining exterior door locksets also used Delrin knobs on the interior with brass on the exterior.

The main garage door is a 9′ x 7′ surface mounted bi-folding unit with hardware specially developed by Stanley Hardware. The door panels are 28″ x 84″ with ⅛″ plywood skins and a polystyrene foamed core. They were factory finished, white, requiring no field finishing. The doors were surface mounted "on the opening," with the weight of the doors on the hinges, and the head track serving only as a guide. This head track slopes away from the wall so that the doors fold against the front wall when open. The cost of this door is expected to be less than conventional garage door units, and the installation is fast and operation is smooth. The ease of opening these doors is considerably better than most swing-up, roll-up or sliding garage doors.

One of the advantages of this type of door is that it can be partially opened to allow pedestrian entry. With the insulated foam core and neoprene weather stripping surrounding the panels, this makes it feasible to heat the garage. A simple foot operated hold-back device is located on the wall adjacent to the doors, securing the door when completely open. It is probable that a low cost automatic opening device could be designed for this unit. These doors were not designed for high priced houses, but for economical garage door installations for medium and lower cost housing. One drawback to this type of door is the limited width which can be utilized: 9′ in width is the maximum anticipated for a bi-folding surface mounted door, thus requiring separate installations where two car garages are used.

ERECTION AND SEQUENCE

The basic crew used to erect the Research House comprised four carpenters, two laborers, and a supervisor. Michigan State University students helped on many occasions, but, essentially, most of the erection was accomplished with the crew mentioned above. A neon sign hanger's boom, mounted on the back of a flatbed truck was used to erect the plumbing core wall, the masonry skin panels and the roof panels. This boom rotated and could

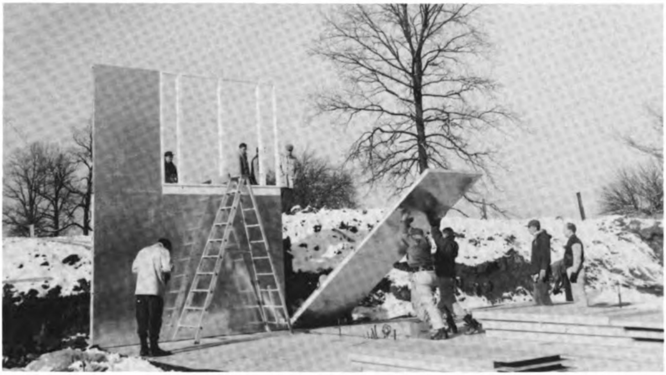


FIGURE 11 — *Rear retaining wall panel erection*

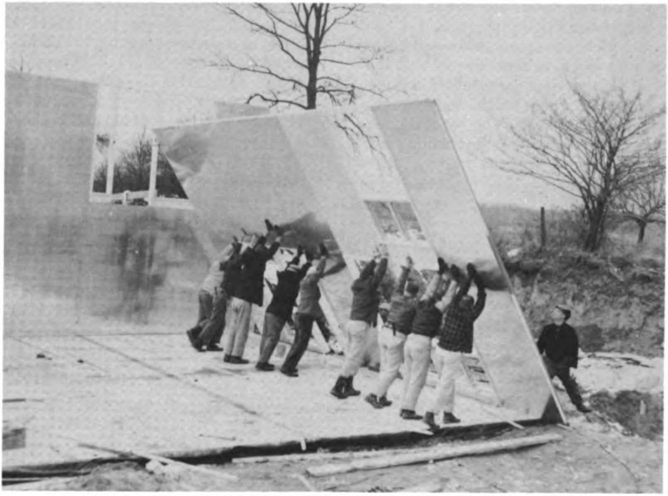


FIGURE 12 — *North wall being raised*

be extended to 55′. Although limited in the amount of load, it was more than adequate for the erection of these units.

The floor slab was started on Monday under freezing weather conditions. The fine grading of the sand leveling bed was first accomplished, and the membrane was laid down and tacked to the plate over the leveling bed. Next the aluminum hold down straps were nailed to the inside face of the plates located at the vertical wall panel joints. The floor panels were then laid in the north bay beginning at 2.30 PM. (See figure 5.) The center and south bay required cut-outs of the panels for the house sewer, clean-out, water and gas piping. This floor slab was completed at approximately 5:00 PM. Total time—2½ hours.

That night there was a 6″ fall of snow. The next morning, after the snow had been cleared from the slab, the wall panels were unloaded from the van. Wall panel erection began at 10:30 AM. The rear wall panels were raised first, beginning at the southwest corner. Several panels were raised individually to demonstrate the ease of erection with small crews. (See figure 11.) Other sections were erected up to 16′ wide. The entire north wall was fabricated on the lab from 4′ units, and was raised in one single section 28′ wide x 16′ high. (See figure 12.) This required 9 men but fewer men could have been used with the help of wall jacks or other lifting devices.

The interior bearing walls were started from the rear wall and brought out 8′. The two center bay floor panels were laid to the rear of the plumbing core wall. With the use of the sign hanger's boom, the prefab plumbing wall was lifted into place. After connection to the house sewer at the slab, the wall was dropped into place and spiked to the interior bearing walls. Next, a ledger was bolted to the north end wall for connection of the second floor panel units. The north interior bearing wall was then completed to the front of the house and the continuous

FIGURE 13 — *Masonry coated wall panel being installed*

wood header dropped into place over the entire length of the wall. The remaining 4′ x 12′ second floor panels were laid in the entire north bay. Work was stopped at 4:30 PM.

On Wednesday, the three masonry coated panels were unloaded and uncrated. Again with the use of the boom and a special lifting rig, these three panels 4′ wide x 16′ high were raised into place, each panel weighing approximately 550#. (See figure 13.) The remaining 24′ wide front window wall was assembled and connected on the slab and raised in one section. (See figure 14.) The south exterior wall was started about 2.30 PM., first with a 16′ wide unti adjacent to the garage. The remaining 12′ sections of the south wall was assembled on the slab and moved into place.

The south interior bearing wall, one story high, was then completed to the front wall and the header nailed in. The ledger for the second floor was bolted on the south end wall ready for installation of the floor panels. Three center bay and seven south bay second floor panels were installed in the remaining thirty minutes. Work was stopped at 4:30 PM.

On Thursday, work was begun on the upstairs interior bearing wall panels. (See figure 15.) After these were installed the gable end triangular units and the interior bearing wall triangular fillers were in-

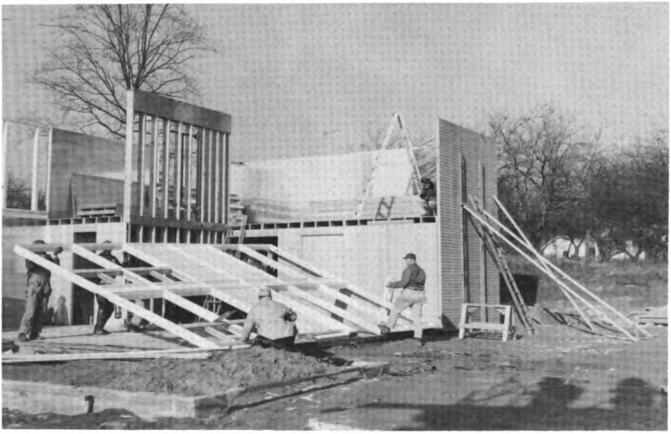


FIGURE 14 — *Front window wall being raised*

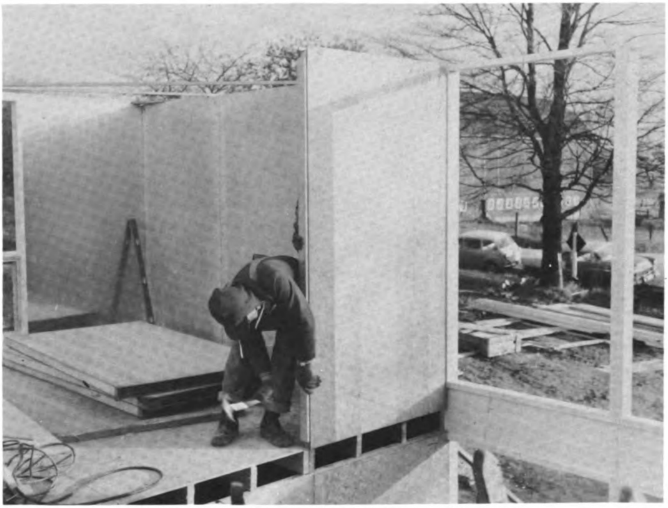


FIGURE 15 — *Upstairs interior bearing wall installation*

FIGURE 16 — *House structure prior to roof installation*

stalled. The ridge tie panels were installed, connecting all four walls at the ridge line. The end of the day produced the structure ready for the roof panels. (See figure 16.)

On Friday the roof panels were unloaded from the van and the cleats were bolted to the underside of the first panels.

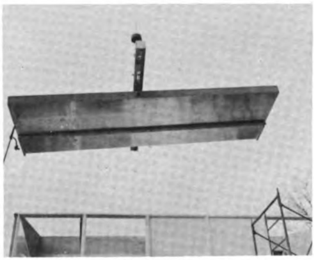


FIGURE 17 — *Roof panel being raised*

FIGURE 18 — *Garage roof panels being installed*

With the use of the boom and the lifting rig these panels were raised individually to the roof and installation proceeded. (See figure 17.) Cleats were bolted to the next panels on the ground as the previous panel was raised and installed. The roof panels were installed and the 2 x 8 fascia spiked at the eave and gable all around. The entire house roof, garage wall, and roof was installed by 5:00 PM. (See figure 18.)

The entire close-in was accomplished in five days including the floor slab. Factory finished exterior wall and roof panels required only joint treatment and final coating of the walls after close-in. This house was complex in design and two-story panels were new and harder to handle than those of one story height. In future installations, the time required to close in this house could be reduced by approximately half.

INTERIOR PARTITION PANELS

The interior partitions were 2″ thick foam core Dylite panels, utilizing two ¼″ gypsum board skins with a 1½″ foam polystyrene core. These panels varied in width from 1′ to 4′. The downstairs panels were approximately 7′-8′ high. The up-

stairs panels were 7′5″ high with filler panels to span over the openings to the underside of the roof. The vertical joints between panels were connected with a typical wood spine. A 2 x 2 wooden cleat was connected to the ceiling in both the downstairs and the upstairs. A recess was provided along the top edge of the partition panels into which this cleat was fitted and nailed through the skins. The bottom connection was accomplished with aluminum clips shaped in a "U" form, connected at the panel joints. The clip was nailed to the floor, and the vertical legs were then nailed to the bottom rail of each panel. Cased openings and doors were edged by inserting a wooden spline at the recessed panel edges.

EXTERIOR WALL COATINGS AND FINISHES

All exterior wall coatings and paints were manufactured by E. I. DuPont de Nemours and Company, Inc. The exterior wall panels were factory coated with an attractive grey long-life Hypalon finish. The retaining wall area received an additional waterproofing material over this finish. All accent panels, window frames, and trim received a long life acrylic exterior house paint.

FIGURE 19— *Sand texturing exterior wall coating*

In the factory, the vertical edges of the exterior wall panels were masked back 1½″ to provide for a field-applied joint treatment. A prime coat of Hypalon was sprayed on the exterior foil face of the panels. A second tack coat was sprayed over the dry prime surface and a quartz sand was spread over this tack coat for desired texture. (See figure 19.) Excess sand was shaken off the panel and a binder coat of Hypalon was sprayed on to produce the factory finish desired. After erection of the wall panels and nailing of the splines a mixture of sand and Hypalon was trowelled on the joints to match the existing panel finish and texture.

At the retaining wall area, the joints between the panels and at the sill were thoroughly caulked with a high grade Hypalon caulking compound. The joints were textured, as noted earlier, and a heavy neoprene waterproof coating was applied up to the second floor water table. The entire house wall including the retaining wall area over the neoprene was field coated with a grey Hypalon to achieve a uniform appearance. With the thick waterproof coating, the Hypalon coating, and the excellent caulking, as well as the aluminum foil, it is expected that the wood and plywood panels below grade will have complete water protection.

The total thickness of the finish on the house wall is approximately 10 mils, with an expected life of approximately 10 to 15 years, or more. The total thickness of the retaining wall is approximately 12 to 15 mils, producing an expected life equal to that of the house. These coatings can receive additional paint when and if it is needed at a later date.

All window frames, trim and accent panels received two coats of Lucite acrylic house paint at the mill prior to delivery. The prime coat was DuPont's Lucite 38, and the second was Lucite 50. A field coat of Lucite 50 was added after the erection when weather permitted. However, the two first coats provided a

satisfactory protective interim finish. The accent panels were in white, orange and yellow, and all frames and trim were in white.

Originally, the garage panels had a tough factory applied PVF film, which promised to produce an extremely long life economical finish. Unfortunately, the film began to peel shortly after delivery to the job site due to a failure of the adhesive. This film was then completely removed and three coats of Hypalon were sprayed on the exterior walls and the field applied battens.

ROOFING AND FLASHING

The roof panels of the house and the garage are factory coated with a tough textured plastic coating manufactured by BB Chemical Company. This roof is a dark grey sand textured finish, utilizing urethane plastic coatings. The advantage of pre-applying the roofing is in the reduction of the time required for closing in, plus factory control for weather resistance and cost. The speed of erection, however, must not be hampered by the required joint system. Thus, a rapid and satisfactory joint system must be developed to produce good weatherability as well as speed.

The house and garage roof panels were masked back at the joints in the factory with 1½″ wide masking tape for future field jointing. A thick urethane prime coat serving also as a tack coat was laid over the epoxy primed aluminum foil on the top surface of the panels. Sand was then spread over this tack coat surface with the use of a hopper. Excess sand was shaken off the panels and the urethane binder coat was applied over the sand, providing the final uniform finish on the panels.

After the panels were erected and the splines securely nailed, the 3″ wide exposed joint was then cleaned. Centered on this joint, a 1″ wide vinyl tape was laid down with a roller. This flexible vinyl tape helps to bridge the joint and expands and contracts with the movement of the panels, eliminating expansion and contraction at a concentrated point in the rigid textured tape. A solvent adhesive was brushed over this tape and the remaining width of the joint. A 3″ wide tape, sand textured to match the panel coating, is laid over the adhesive and rolled down. This semi-rigid tape is bonded to the foil face of the panels at the outer 1″ on either side of the flexible vinyl tape. In this manner the more rigid finish tape can move over a less concentrated width.

Experience from this project has shown that the taping system used does not produce a lasting weather-tight roof. Apparently some of the tape and adhesive joints were not firmly bonded. It was decided to cover the house roof area with asphalt shingles. The garage roof however, will remain exposed and as yet has not produced any leaks. Experience over a long period on this garage roof will prove invaluable as to the weatherability of this type of system. The urethane roof coating itself did not fail and produces a durable, attractive, pre-finished roof coating material. As a result of experience from this house, development is now underway on plastic compression seals as a joint weather-tight joint system. Results of this work should produce a pre-coated roofing which will be complete once the panels are installed, and no loss of time will be

FIGURE 20 — *Neoprene vent flashing and urethane roofing*

necessary for additional joint treatment. Ultimately it is hoped that by the use of factory coated roofing, roofs can be attained which will reduce on-site labor, produce attractive roofings of various colors, and provide a long life with low maintenance cost.

The vent stack was flashed with a preformed neoprene unit known as Carlton Mono-Flash. (See figure 20.) By caulking at the pipe, and the overlap of the roofing, this unit provides a good weathertight seal. The ridge cap, the flue and fan housing flashing, and the flashing at the garage roof to the house wall used a Hypalon sheet 6″ wide. This flashing was solvent welded with an adhesive to the pre-coated roof and wall coatings, thoroughly sealing all flashed areas against the weather.

All gravel stops and fascia flashing at the gutters was .020″ x 4″ aluminum formed to the desired shape. Gutters and downspouts were aluminum, pre-finished in a long life white acrylic paint. An interesting innovation was a gutter guard of Alathon polyethylene. This product is a scalloped edge half circular section which keeps leaves out but provides free flow of rainwater to and in the gutter.

MASONRY WALL COATING

A 12′ x 16′ high masonry coated accent wall was used on the front wall. These wall panels were Dylite asbestos cement skin units with a factory applied mortar and brick-like coating. Although this material is not new, factory coated Pan-L-Brick is an innovation, producing economy and control never before achieved.

Over the exterior asbestos cement face, a grout wash is applied, and a mortar coat of Portland cement and sand, $\frac{5}{16}$″ thick, is spread on with a trowel. A $\frac{1}{16}$″ layer of ground and re-constituted brick with a cement binder is applied over the firm wet mortar coat. After applying the brick coat, a template of desired pattern is laid on the surface and a routing tool removes the brick down to the mortar coat, producing a simulated mortar joint. Various textures as desired can be achieved. The brick color on the Re-

FIGURE 21 — *Masonry coated wall panel*

search House was an orange brown and the pattern was roman stack bond. (See figure 21.)

After the panels were erected, the splines and plate were nailed through pre-drilled holes in the exterior coating and skin. The joint between the panels was grouted with mortar and the nail holes were buttered. Factory coated brick panels are expected to be substantially less than the cost of typical veneered systems. This panel produces excellent insulation and vapor barrier with a desired masonry finish.

PLUMBING

A prefabricated plumbing core wall was used in this research house. This wall was conventionally stud framed with all rough waste, vent and water pipe installed therein. (See figure 22.) The wall was constructed with 2 x 8 studs and was 12′ wide x 18′ high. The total weight of this core wall including pipe was approximately 800#. This unit was assembled in the plumber's shop and all rough plastic pipe was installed at that time. After the wall was raised in place, the house sewer was connected to the vertical stack. (See figure 23.) The hot and cold water lines projecting from the south end of the wall were later connected to the water service and hot water heater. Although this unit was heavy, a one-story plumbing core wall using plastic pipe would be much smaller and lighter.

FIGURE 22 — *Plumbing core wall installation*

All waste and vent pipe and fittings were PVC Tuftite manufactured by Colonial Plastics. Schedule "A" wall thickness was used which is specifically designed for an internal pressure of 100 psi, and pipe sizes range from 1½″ to 4″. Solvent welded connections were used throughout, the solvent merely brushed on both parts to be connected. Solvent welding fuses the pipe and fitting and provides an excellent permanent connection. Most fittings required were available. However, several fittings were specially made by cutting and welding to produce the desired unit. This is advantageous where time will not allow waiting for delivery of special fittings. As volume increases a wider line of fittings will become available.

The hot and cold water pipe and fittings were a new plastic material manufactured by B. F. Goodrich Chemical Company. This product is known as Hi-Temp Geon which is basically a vinyl dichloride. Tests and experience data demonstrate the ability of this product to withstand relatively high residential temperature and pressure conditions. This material has been tested in a test cabinet for over 10,000 hours, at 190°F and 500# pressure with no appreciable creep. Schedule 40 pipe was used throughout in 1″, ¾″ and ½″ diameters. All plastic pipe and fitting connections were made with solvent welding methods as previously outlined. Connections to metal fittings were accomplished with the use of a plastic to copper adapter. A short section of Hi-Temp Geon was connected to a short copper pipe with an "O" ring seal. The plastic pipe was enlarged by

FIGURE 23 — *Close-up of plumbing core wall at slab*

heating so that it was slipped over the pipe and ring. When the plastic cools it returns to its original diameter, clamping securely to the "O" ring seal and provid-, ing an excellent water tight connection. The only metallic pipe used was at the fixtures.

Water for the house was obtained from a well, drilled 10′ south of the garage. It was drilled to approximately 200′ depth and utilized a submersible pump. The pressure tank was located in the southwest corner of the garage and was supplied from the well by a 1″ polyethylene service line. From this tank distribution to the hot water heater and the plumbing core wall was through a ¾″ soft copper line located under the slab. Additional lines under the slab were run to the required sill cocks on the exterior of the house. Due to the high degree of hardness experienced in well water in this area, a water softener was used. This unit was installed in the line adjacent to the pressure tank in the garage.

The house sewer under the slab was 4″ cast iron pipe, and a clean-out was located under the base cabinets in the east wall of the kitchen. A cavitat sewage treatment tank was located at the northeast corner of the terrace at the front of the house. This treatment unit has a motor-driven impeller which reduces the pressure at the bottom of the shaft and draws air to the first compartment of the tank. This air supports the aerobic bacteria in the digestion process. Constant movement is maintained by the action of the impeller which increases the efficiency of operation. Reduction in Biochemical Oxygen demand can be obtained up to approximately 85%. The aerobic effluent has different absorption characteristics which makes it possible to reduce the size of the effluent absorption field.

The drain field used for this house was 250 lineal feet of 4″ Tuftite PVC perforated pipe. This pipe was laid in trenches 2′ wide and 2′ deep and was located approximately 18″ below the ground surface. The pipe was laid in gravel to insure more uniform distribution in the absorption field. The entire sewage disposal system was designed and supervised by members of the engineering department at Michigan State University.

An aluminum alloy tank gas-fired water heater of 50 gallon capacity was used in this house, and a Duo-Temp apparatus attached to this water heater provides hot and super-hot water as required. The clothes washer and the dishwasher received 180°F water, on a separate line from the adapter. The remaining hot water lines are supplied by water at a temperature of 125°F. Increased washing efficiency results from the use of high temperature water, preventing the scalding of hands for normal use when this Duo-Temp apparatus is installed.

A unique new economical single handled tub and shower mixing valve called "Dialset," manufactured by Moen Faucet Company, was used. This unit was used in the shower of the master bathroom and tub-shower of the hall bathroom. This fixture is an extremely simple self-contained and self-lubricating assembly which insures long life. The valve cartridge is easily removed and can be replaced if needed. No working parts are built into the wall so that all replaceable parts are easily removed. The operation of this unit is simple; pull-out for increased pressure and rotate to the left for hot water and right for cold water. A further advantage of this valve is its adaptability to back-to-back installations. By removing the valve cartridge and rotating 180°, the necessity for crossing the water lines is eliminated.

A number of nylon plumbing assemblies were used in the research house. Plastic such as nylon reduces corrosion, provides self-lubrication and long life. Water closet ballcock assemblies used Delrin nylon, and were installed in each of the water closets of the house. Center-set lavatory fittings incorporated valve assemblies using Delrin. These fittings required a shorter action and reduces the effect of water hammer normally experienced in lavatory fittings. A spring in the valve assembly absorbs a large portion of the water hammer. Zytel nylon shower heads were used in both upstairs baths, which incorporated flow adjusters for volume control. The toilet seat hinges were of Zytel nylon.

FIGURE 24 — *Molded fiberglas double bowl vanitory*

A one-piece fiberglas shower stall and a double bowl vanitory were provided by National Fiberglas Company. The shower stall was 48″ wide x 32″ deep and 8″ high, and was manufactured with the pan and three walls in one piece. A separate hood was used to provide a ceiling. The double bowl vanitory was 21½″ deep x 60″ wide with the bowl, top and backsplash molded in one piece. (See figure 24.) Both units were provided in white with gold fleck. These fiberglas units provide an attractive, rapidly installed, easily cleaned and less expensive installation than conventional methods.

The shower door in the master bathroom is an aluminum frame folding plastic unit. This unit utilizes Alathon polyethylene folding panels, and can be folded to the wall allowing greater access than sliding doors. This door is installed easily and is economical. The tub enclosure in the hall bathroom is a sliding door unit with decorative vinyl panels in an aluminum frame. Imbedded reinforcement simulating grass cloth was pressed in an opaque light grey vinyl sheet, providing an attractive shatter-proof door which is easily cleaned.

All remaining plumbing fixtures were conventional and were provided by Briggs

Manufacturing Company of Michigan. White fixtures were used in the upstairs bathrooms and beige colored fixtures were installed in the downstairs powder room. The kitchen sink was a single bowl 24″ wide white porcelain steel unit.

HEATING, COOLING AND VENTILATING

A gas fired forced air furnace was selected because of the economy and availability of gas in this area. It was decided to air condition this house since humidity in the Lansing area increases the discomfort during the warm Summer months, and to obtain operating costs for a well insulated house in this area.

The heating and cooling equipment was furnished by Bryant Manufacturing Company. A gas fired, forced air furnace was used with an input of 125,000 BTU's and an output of 100,000 BTU's. This unit has a fan capacity of 1400 CFM which was sized for the air conditioning. Cooling coils, mounted on the top of this upflow furnace, have a rated capacity of 36,000 BTU's. The furnace unit measures 24″ x 29″ x 56½″ high and the coils are 19″ x 24″ x 17″. The furnace and coils are located in a small enclosure in the family room adjacent to the water heater. The cooling condenser is a remote unit, gas-fired, 36,000 BTU output model. This unit measures 40″ x 48″ x 52″ high and is located on a concrete pad at the rear of the house behind the upstairs bathrooms. 1″ polyethylene pipe was used for the chilled water lines to the coils, thus requiring no additional insulation. The condensate line from the coils was connected to the washer waste vent in the plumbing core wall.

The main feeder duct was exposed in the family room and ran from the furnace to the front wall of the house. (See figure 25.) To the rear of the furnace, the feeder duct was framed in. The exposed duct was 27″ wide x 8″ high with an attached light troffer measuring 5″ x 2½″ for strip fluorescent lighting. All exposed portions of this duct and troffer were vinyl coated 22 gage steel provided by United States Steel Corporation. This

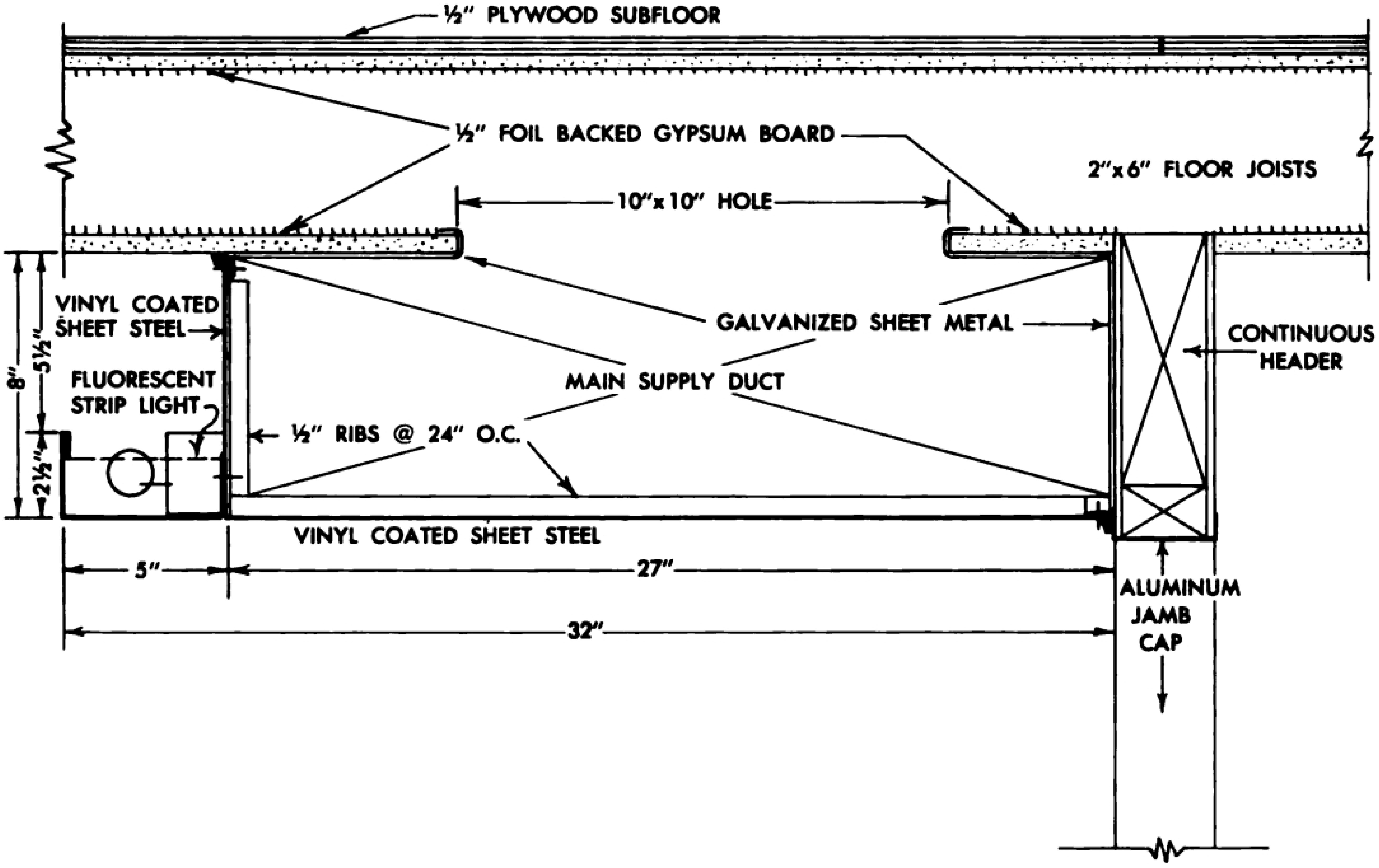


FIGURE 25 — ***Detail of exposed supply duct and troffer***

FIGURE 26 — *Finished view of supply duct and troffer*

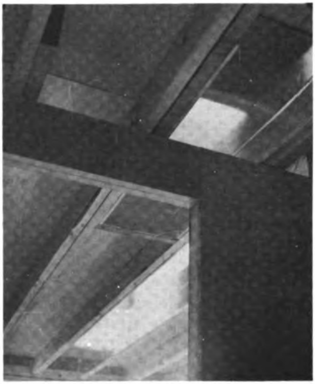


FIGURE 27 — *Foil faced gypsum board duct lining*

vinyl clad steel was post-formed in the desired shape on a break at the sheet metal shop. A grey vinyl in a grained texture was used, providing an attractive pre-finished material, quite suitable for exposed metal uses. (See figure 26.) The unexposed portion of the duct was galvanized steel, which was securely fastened to the wall and the ceiling. Chrome head screws connected the vinyl steel portion of the duct to the unexposed fixed portion. Steel ribs supported the soffit from sagging and served as a backing for the fluorescent lights in the troffer.

This main feeder duct supplied air through holes in the gypsum board ceiling to selected joist spaces. These joist spaces were lined with a single piece of ½″ aluminum foil backed gypsum board protecting the subfloor and each joist. (See figure 27.) With foil backed gypsum board on the ceiling, a completely lined duct was accomplished. The downstairs was supplied by ceiling diffusers located in the center of the rooms, and floor registers for the second floor were located at the outside walls. Each register was located on a separate joist lined duct, thus eliminating any through sound transmission from room to room. A boxed-in steel duct was required at the front of the entry for a register in bedroom #3. The framing for boxing in this duct served to support the large window wall in this entry against lateral forces. Lined joists spaces using aluminum foil backed gypsum board are inexpensive and practical, producing the desired protection from the heat experienced in warm air systems. This method, however, has not received approval of the National Bureau of Fire Underwriters.

Aluminum ceiling diffusers, 10″ round, were used in the living room, family room, dining area, and breakfast area. Two 5″ x 12″ dampered wall registers were used in the south wall of the entry. A 5″ x 12″ register was located in the garage at the ceiling area to provide heat for this area. In each upstairs bedroom, two 4″ x 14″ steel dampered floor registers, were located, one on each of the outside walls in these rooms. A 12″ x 24″ fixed cold air return aluminum register was located on the wall near the ceiling at the ridge line in the upstairs hall. This register fed through a plywood lined duct which also served as a light soffit over the vanity in the hall bath. This duct then ran down the corner of the hall bathroom

into the utility room below, and then into the base of the furnace. Fresh air blending was obtained through a hole in the roof under the flue housing into this cold air return. A 24″ x 18″ aluminum cold air return register was located on the furnace room wall at the breakfast room. This cold air return register was dampered, which allowed balancing of the system. A small combustion air intake duct was located in the furred space in the breakfast area to the rear of the house wall, and a water proof grille was located above grade on the retaining wall to supply fresh air for combustion.

The flue for the furnace and the water heater was located in a furred space located in the southeast corner of the kitchen downstairs and master bath upstairs. A double lined insulated 7″ steel flue was used which is adaptable to all types of fuel and heating equipment. This flue has an outside jacket diameter of 13″. The flue discharged through the roof in a prefabricated steel chimney. This chimney housing was 19″ wide, 34″ on the pitch of the roof and 46″ high, with a weather-protected housing at the top. Louvres in the side of the chimney allowed for fresh air intake for blending with the cold air return.

The ventilation exhaust system for the research house was unique in that 3 fans with a single roof exhaust housing were used to remove the air in 5 rooms. This system was designed and built by Emerson Pryne. (See figure 28.) One fan exhausts the kitchen and utility room, a second exhausts the two upstairs bathrooms and the third fan exhausts the downstairs powder room. These three units are located above the plumbing core wall in the furred attic space located above the upstairs bathrooms. Vertical ducts located in the core wall carry the exhaust air from the registers in the rooms to the fans. A single duct with a double register is used for the two bathrooms, and the kitchen and the utility room use a similar system. The three fans then discharge into a single horizontal duct which carries the air to a central plenum. A single roof housing is located over this plenum and an 8″ x 16″ hole in the roof is the only puncture necessary. When exhausting two rooms the fans are switched in parallel, and access for maintenance of the fans is achieved through the removable luminous ceiling in the hall bathroom. A single dual room exhaust system such as used in this research house is adaptable to back-to-back bathrooms, and provides ventilation at a lower cost than can be accomplished with individual fans for each room.

ELECTRICAL AND APPLIANCES—

The electrical power service entrance is located at the front left hand corner of the garage. The meter is mounted on the outside of the garage wall, and from this meter underground conduit carries the power to the main service panel located in the utility room on the mechanical core wall. The panel is a 200 amp 18 circuit unit from which the power source and controls for the water pump and cavitet sewage unit are located. A 220 volt outlet is provided for the dryer in the utility room and a separate appliance circuit is provided for the dining area. The furnace fan and the cooling condenser are each on separate circuits as well as the hi-fi intercom located in the living room. The remaining circuits are the household convenient outlet and lighting circuits.

A three-wire circuit was also run to a sub-panel located under the stove in the kitchen. (See figure 29.) This sub-panel contains four circuit breakers for the four load circuits in the kitchen. The range and oven and the appliance center are each on a separate circuit. The dishwasher and garbage grinder is on one circuit and the kitchen and breakfast room appliance circuit complete this subpanel load.

All two wire circuits utilize a new type non-metalic cable. Two vinyl insulated #12 wires with a bare ground were encased in a semi-clear Zytel nylon insulation. This Zytel insulation provides considerable increase in insulating efficiency, allowing a reduction in the thickness of

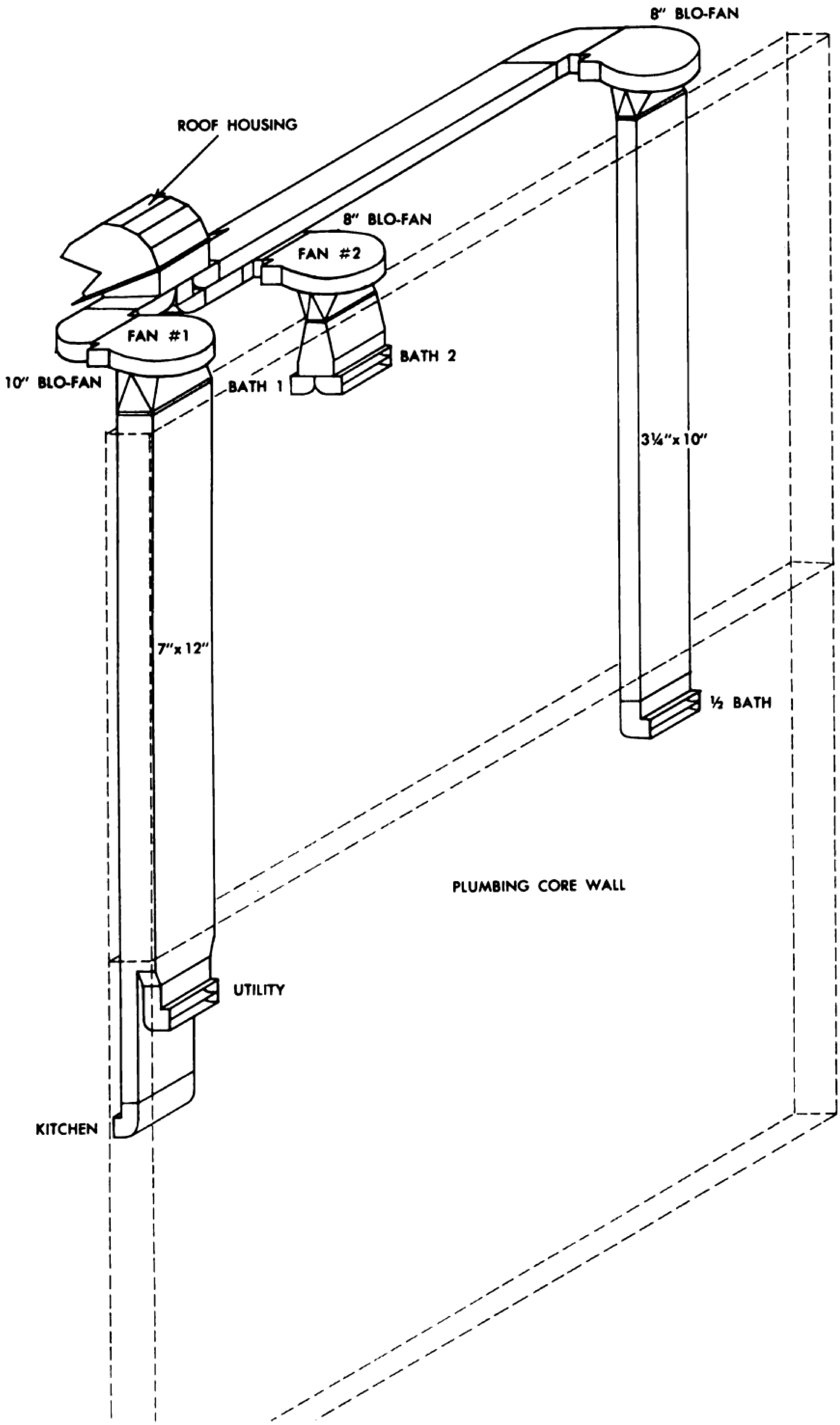


FIGURE 28 — *Isometric of central exhaust system*

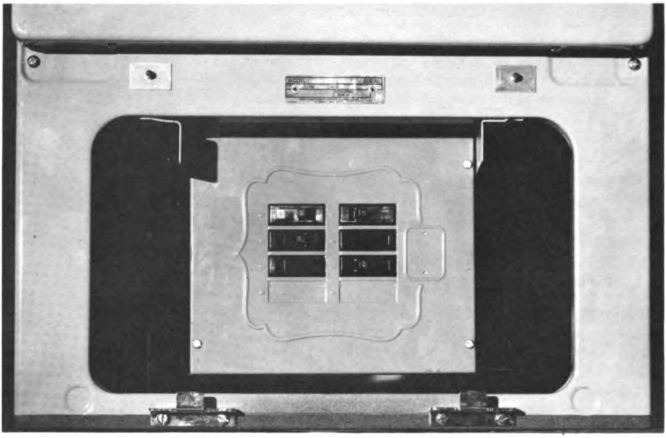


FIGURE 29 — *Close-up of range sub-panel*

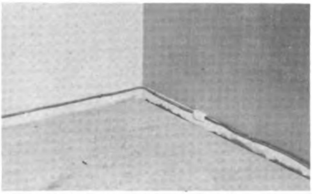


FIGURE 30 — *Electric cable and outlet mounted on wall*

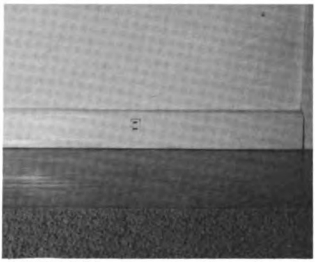


FIGURE 31 — *Rigid vinyl base board with electric outlet*

insulation required. The material is extremely tough and durable and the resultant smaller cable sizes allow easier fishing in the vertical wire chases of the Dylite wall panels. Wiring from the main panel is distributed through the second floor joist area to the walls where the wires run vertically in pre-formed wiring chases located on either side of the panel joint splines. All wall switches, lights and outlets were located adjacent to these splines, and convenience outlets and the wire in each room is mounted on the wall surface and covered with a hollow vinyl baseboard.

Wiring for the convenience outlets is pulled through the panel skins of the wall at the base, and the non-metallic cable stapled to the wall approximately 2″ above the floor. (See figure 30.) Single porcelain receptacle outlets were screwed to the wall and wired with friction connections to the cable. The rigid vinyl hollow baseboard is 13/16″ x 3″ and covers the cable and receptacles. Cut-outs in the baseboard allow the plug portion of the receptacle to project through the base. (See figure 31.) This hollow base

contains two compartments which are divided by a double fin where screws for connection to the walls are made. The double fin protects the cable and wire from damage when connecting the base with screws or nails. The upper, or larger, compartment carries one or several line voltage cables and the smaller lower compartment is for low potential uses including telephone wire. All wiring and outlets are given Underwriter's approval and installed in accordance with the National Electric Code. The baseboard is grey in color and can be painted as desired to suit the decor.

National Electric Division of the H. K. Porter Company developed this system after several meetings with the Research Institute staff, Michigan Bell Telephone and Detroit Edison. All of these organizations recognized the problem of surface wiring which is necessitated by sandwich panel or solid wall construction. This system provides an economical approved method of wiring which allows the desired location or addition of outlets after the basic wiring is installed. In addition, it is adaptable to any type of construction with definite advantages for sandwich panel or solid wall construction. Of considerable interest to the utility companies is the adaptability of this system for additional wiring and outlets after construction is completed. Should the electrical system in the house require additional loads such as room air conditioners, additional wiring can be easily installed with this removable base system. The plastic cover serves double purpose as a wiring raceway and baseboard, and can be removed at any time.

Telephone wiring was installed during the construction and designed to provide an adequate number of telephone outlet jacks. A new concealed wiring method recently developed by the Bell System known as the continuous loop system was used. A terminal box is located in the central utility room, and two continuous loops were installed for the telephone outlets desired. One loop is for the north side of the house and the second is in the south area. The wire consists of six twisted pairs of insulated 24 gage copper wire and the recessed outlets are a standard block of Bell Telephone jacks.

Lighting for the house is generous and effective. The kitchen, upstairs bath, powder room and upstairs hall alcoves utilize luminous ceilings, since these rooms do not have natural lighting. A suspended 1 x 2 wood eggcrate framing supports 90 mil sheets of clear nylon reinforced lucite plastic. Fluorescent lighting above the luminous ceiling created an extremely attractive appearance with excellent light distribution and density. Although the plastic was basically clear, it was not transparent, and served to hide mechanical equipment and diffused the strip lighting located above it. Indirect lighting in the family room was provided by strip fluorescent tubes in the light troffer of the heating duct. Attractive light fixtures in all major rooms were provided, and the dining area utilized four dimmer controlled flush ceiling lights around the chandelier for desired light density. Exterior lights and spots provided well-lit terraces, patio, entry walk and playdeck. These exterior lights were located on the corner soffits of the roof overhang and the wall adjacent to the terrace and entry.

A new built-in hi-fi stereo intercom was supplied by NuTone Inc. These units were mounted in a framed alcove on the south side of the living room and contained a separate amplifier, tuner and record player. (See figure 32.) These units were framed into standard 2 x 4 construction. Two living room speakers located 10′ apart provide stereo roproduction in that room, and the remaining rooms contain single speakers which transmit monaural reproduction. A front door answering speaker is used and a waterproof speaker on the patio is provided. The master control panels are located on the amplifier and each speaker contains individual controls for volume and intercom speaking. The record player is a binaural automatic unit, and the amplifier utilized dual channels for stereo reproduction. Record storage is provided below the control units on two shelves 5′ wide, with sliding doors. Two 5′ wide

FIGURE 32 — *Hi-Fi stereo control unit in living room*

bookshelves are also provided in the alcove above the control units.

The appliances used in the research house provide the latest in kitchen facilities. A built-in counter-range-oven was provided by Westinghouse Electric Corporation. This unit, built to specifications established by the Research Institute, was 24″ wide, providing an undercounter oven with three counter-top range elements. Controls for the elements and the oven were located where the fourth element normally exists. An appliance center was provided which included a timer, two cord reels and two outlets. With the greater use of small appliances, this center serves to replace the need for the fourth range element. The sub-panel for the kitchen circuits was mounted below the oven with an access panel for maintenance. This sub-panel can be replaced and a storage drawer substituted.

A 24″ undercounter dishwasher was provided and located to the left of the sink. This sink contained a garbage grinder, and a 12 cu. ft. refrigerator was located on the opposite side of the kitchen. A NuTone Kitchen Center was installed on the rear counter adjacent to the refrigerator. Westinghouse Deluxe Space Mate clothes washer and dryer are stacked vertically in the utility room. Water controls for these units are located in the divider panel between the units for easy access.

KITCHEN CABINETS AND MILLWORK

The kitchen cabinets embody an economical knock-down, job built system. (See figure 33.) Aluminum extrusions were utilized as vertical supports for the shelving in both the upper and lower cabinets of the kitchen. The aluminum extrusion hanging system for the kitchen cabinet shelves utilizes a unique system of connection for both hardware and shelves. This extrusion provided slots into which bolts with grippers could be used to con-

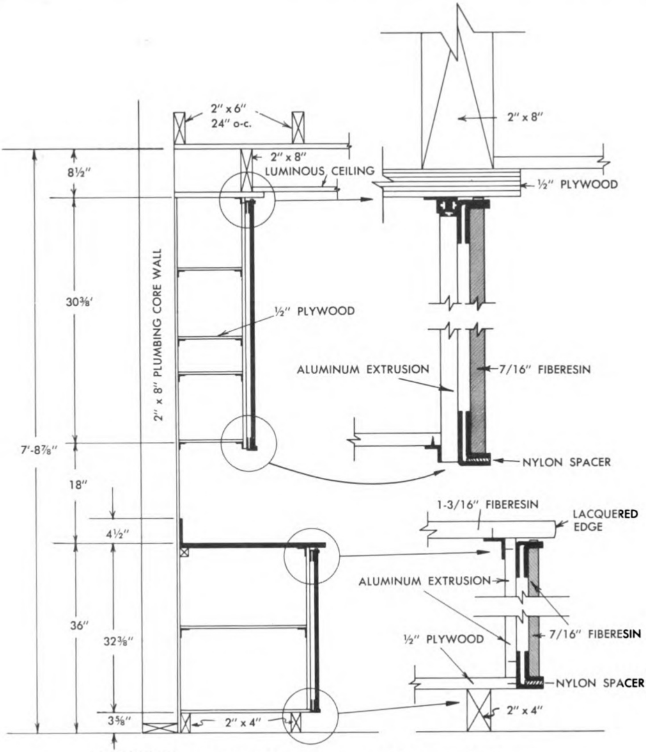


FIGURE 33 — *Vertical detail section of kitchen cabinets*

nect the supporting hardware pieces. These clips were adjustable so that shelving could be moved up or down to suit the desire of the owner. Similar clips were mounted on the wall at the stud locations to provide complete support for the shelves, and clips mounted on the front face of the extrusion served to support the door hinges. The door hinge piece contained studs which fit into holes in the fixed clip, and a nylon clevis is placed in the bottom hinge after the door is positioned. The doors are rapidly installed or removed, and accurate positioning of the vertical aluminum extrusions is necessary so that there is no binding between door units.

The kitchen counter-top utilized

FIGURE 34 — *Kitchen showing Fiberesin counter top and doors*

Fiberesin as its material. This is a high density particle board with melamine plastic surfaces, with the exposed surface incorporating a print with the desired pattern. (See figure 34.) The cabinet doors are also Fiberesin as well as the end panels of the cabinets. The counter-top is a self-edged 13/16″ thick unit with a 4½″ backsplash. The cabinet doors are 7/16″ thick, with finished lacquered edges. The end panels of the kitchen cabinets are of 3/16″ material. The hall and master bath vanities utilize similar construction in the doors, tops and end panels.

The drawers in the kitchen cabinet system utilize high impact polystyrene molded units with metal hardware, and the faces of these drawers are 7/16″ Fiberesin. The counter-top and lower cabinet doors are off-white with gold fleck, and the upper kitchen cabinet doors are a charcoal gray with gold fleck. The hall bath vanity utilizes a dark black pattern with gold fleck and the master bathroom is in white with gold fleck as used in the kitchen.

A type of construction similar to that used for kitchen cabinets was utilized for the storage and linen closet at the top of the stairs in the hallway. Vertical extrusions of aluminum with pre-finished plywood as the surfaces comprised the construction of this unit. This aluminum extrusion system affords a great deal of flexibility in the design of free-standing and fixed closets and cabinetry.

A unique clothes hanger bar was used in all wardrobes. This unit is constructed of a cold rolled sheet steel apron, and is connected to the front of the closet shelf extending down and rolled back to the unexposed side, so that a clothes hanger can be hung from the back edge. With the use of this steel shelf apron, 9′ of clear shelf can be used, eliminating the need

for a center support. A small single cleat at the rear of the shelf and the end hook strips are all that are necessary when this apron is used. The apron hides the front edge of the shelf, and can be painted with the trim of the closet.

The medicine cabinets for the upstairs baths are twin units fitting in standard stud spacing. A metal divider serves to cover the center stud and connects the two individual cabinets. Door swing on the cabinets are opposite for easier access.

INTERIOR DOORS AND HARDWARE

All interior doors are surface mounted with hardware specially adapted for such installation. The passage doors were manufactured by the U. S. Plywood Corporation, and are constructed with two sheets of 3/16″ pre-finished Candlelight Samara plywood. They are glued together at the edges of the door and are parted at the job site with a wooden spline inserted at the center, creating a bowing of the skins. By inserting this spline between the two sheets, the skins then become stressed, reducing the possibility of warpage. The doors were surface mounted on the opening with an adaption of Surfaset hardware manufactured by Stanley Hardware. A black steel handle was specially designed for the bowed doors, creating an attractive installation. Sheet aluminum channels of .024″ thickness serve both as trim and jamb to encase the opening. These channels were connected to the partition openings by an adhesive to provide a permanent and attractive installation.

The closet doors utilized both swinging and bi-folding units, and all doors were surface mounted using Surfaset hinges. The bi-folding doors used a new pivoted surface mounted bi-folding track developed by Stanley. This track located and mounted at the head of the doors on the wall, is pivoted at the center. The guide studs at the top of the door pivots the track out as the doors open, thus allowing for free swing of the panels. The remaining closet doors were surface mounted swinging units with magnetic catches.

A shoji sliding door serves to compartment the hall bath. These doors use polyester sheet plastic in a black painted wood frame, which provides the necessary privacy, but allows light through the translucent plastic sheet.

STAIRS

The stair of the MSU Research House incorporates a unique structural design with an attractive appearance. (See figure 35.) Essentially, it utilized a box stringer with open cantilever treads, and it was a scissor type stair with two runs and a landing half way up. The box stringer was constructed using two 2 x 14's with ½″ plywood gussets on the side and a ¼″ plywood soffit. This box stringer was 13″ wide over-all. The treads were 1⅛″ x 11½″ x 42″ long oak planks which cantilevered 14½″ on either side of the box stringer.

A new style aluminum hand rail system which is flexible over a range of stair pitches was used on this stairway. This hand rail system consists of ¾″ aluminum rods with a vertical slot at the top to receive a "T" shaped rail, with set screws to lock the "T" hand rail in place. At the tread, the ¾″ rod was reduced to ½″, passing through the tread, and it was threaded for approximately ½″ below the tread. A ¾″ cap threaded on the rod was then screwed tight to the bottom of the tread. A vinyl cap which was heat-applied to snap over the aluminum "T" was utilized as the finish hand rail. Miter joints were heat-sealed and end caps were heat-applied. When the vinyl cooled, it became permanently fixed to the hand rail system.

The oak treads and landing were sanded and finished with a urethane floor varnish. This finish produces a hard durable surface which will maintain its finish over many years of wear. The box stringer was painted black, contrasting with the the treads and entry decor.

In the design of the entry and stairway, the entire area underneath the stairway was utilized as a planter with a curb

FIGURE 35 — *Entry stairway with planter beneath*

formed from a 2 x 6. The entire area within the planting box was filled to within several inches of the top with white gravel. The ceramic tile flooring in the entry ran up the face of the 2 x 6 and the entire curb was capped with a pre-shaped aluminum cap strip. The final result of the stair and entryway was extremely attractive, adding to the complete openess of the entry. The front area, 8′ x 12′, of the entryway was open for two floors with a cathedral ceiling above. A feeling of considerable spaciousness was obtained through this design.

INTERIOR FINISHES

The ceiling areas of the family room and living room are unique in that they provide a method of finishing drywall in one day with the use of a new development in gypsum plaster. This system can be applied directly to the gypsum board without the necessity of taping. It was developed by Compton Products Company. (See figure 36.) A less expensive type of gypsum board can be used without the manila paper face, allowing for greater economy. It is applied in two coats. The first coat is applied approximately 1/32″ thick with a trowel application, and dries rapidly allowing the application of the second coat within twenty to thirty minutes. The second coat can be either troweled on or applied with a special spray gun. In the case of the Research House, the texture coat was sprayed. It contains a Perlite aggregate which creates an acoustical plaster appearance. The front wall of the living room received the same treatment except the second coat is a flat trowel finish. This gypsum product has an extremely high strength, in the neighborhood of 4000 psi, thus permitting application over non-taped gypsum board joints. At present, the development of this material does not include integral color. However, eventually this can be obtained. In the case of the Research House a coat of paint was applied over this finish. It is estimated that two men and one laborer can apply approximately 1000 sq. yds. per day which equals approximately two small houses. By this system, the time normally required for finishing gypsum drywall is reduced by three days, and the approximate cost is equal to conventional drywall finishing methods.

FIGURE 36 — *Spray application of hard coat ceiling treatment*

The ceiling area of the upstairs utilized three patterns of fiber acoustic tile as manufactured by Armstrong Cork Company. These tiles, it was found, provide excellent sound dampening in areas which normally create a great deal of noise. This acoustic tile, in 1′ x 1′ squares, was applied by mastic to the underside of the aluminum foil skins of the roof panels. Acoustic tile was selected for this job for two reasons: first, to eliminate the excessive noise which can be found in a house designed for a large family; second as an excellent means of finishing the plywood panels used for the roof system. Although more expensive than conventional finishing methods, it is rapid to install and provides functional benefits which are not normally found in most residential dwellings.

Most of the exterior walls have a canvas fabric wall covering which was found to be good in the finishing as well as decoration of plywood skinned panels. By the use of this strong covering, any dimensional movement found in the panels would have little or no effect on the finish applied thereon.

The interior load-bearing partitions whose skins were made of raw plywood were first primed, then a conventional drywall tape was applied to the joints. Normally, this is not a satisfactory means of finishing joints in plywood. However, the results gained from this Research House have been successful using conventional drywall joint methods. A heavy stipple paint was applied over this and to this date, no failure has been experienced in the joint system. All of the interior gypsum board panels were finished in a like manner.

The sidewalls of the entry are covered

with a durable, vinyl Fabrilite wall covering. This material had a grained textured pattern and is white. This material is easily cleaned and provides an extremely good surface in an area normally subjected to a great deal of wear and dirt.

The rear wall of the dining area incorporates a fabric known as Rovana, manufactured by the Dow Chemical Company. This fabric is a woven saran material with an asbestos paper backing. It is easily applied, similar to wall paper, and provides an extremely durable, highly attractive and washable surface. This material is similar in effect to a woven grass-cloth, but costs considerably less. It provides a unique pattern and variation from normal wall covering practices.

At the rear of the entry downstairs, and in the upstairs hall, 3/16″ Candlelight Samara pre-finished plywood was applied to the gypsum board partition panels. The wardrobe walls of each bedroom was also finished with this paneling. The plywood was applied with mastic to the partitions, and it matched the doors, thus creating a pleasant appearance in these areas.

A black Fiberesin with gold fleck was used as a tub wainscoting in the hall bathroom. This material was 3/16″ thick in panels 30″ wide and was applied with mastic. A white vinyl caulking material was used at the joints, corners, and exposed edges.

FLOORING

Oak hardwood strip flooring was applied in the living room and in bedroom #2. Vinyl sheet flooring was applied in the kitchen, family room, utility room and in bedroom #1. Vinyl asbestos tile was laid in bedroom #3 and the playroom. The bathrooms upstairs, the powder room downstairs, and the entryway utilized a unique new ceramic tile mat which is attractive as well as providing advantages in construction time and money.

The living room flooring was a thin 1/8″ thick 3″ wide stabilized strip oak flooring. The upstairs bedroom # 2 utilized the same thin dimensionally stable flooring in a dark African hardwood. This material was applied over an adhesive laid on the sub-floor. The adhesive is unique in that it can be applied over the entire area, and prior to installation is activated by an acetone solvent. The short strips of flooring are then laid on the activated adhesive and hand rolled until firmly set in place. This flooring goes down rapidly and due to the extremely thin section can be applied over concrete or wood subfloor without exposed nailing. This thin flooring is known as Plank-Tyle, manufactured by Nickey Brothers, and is one of the first materials providing a hardwood strip flooring which can be laid economically over concrete floor surfaces. The material is unfinished but an excellent finishing material was furnished which can be applied and made ready for waxing in one day. The finish material provides a filler, sealer and stain, and no sanding is necessary due to accurate manufacture of the strip material. This flooring is less expensive than parquet, fast to lay and due to its short lengths, eliminates wastage due to cutting.

Ceramaflex rubber imbedded ceramic tiles were used in the entryway, both upstairs bathrooms and the powder room. (See figures 37 & 38.) This product

FIGURE 37 — ***Entry way ceramic tile flooring***

FIGURE 38 — *Master bath tile floor (note fiberglas shower curb)*

utilizes 1″ x 1″ nominal ceramic tiles imbedded in a GRS rubber of dark gray which also forms the joints between the tiles in lieu of grouting. The tile mats are 9″ x 9″, 7/32″ thick, using 8 tiles in each direction. This material is laid similar to asphalt tile with an adhesive provided with the material. This is a fast, easy installation with no required comeback for grouting of joints. The rapid speed of installation reduces the time of installing a ceramic tile floor by one day. Furthermore, the dark rubber joints stay cleaner, do not show dirt, and are more easily maintained. This product provides a more resilient and warmer floor than conventional ceramic floor installations. The patterns and colors used in the manufacture of these tile mats create an extremely attractive floor.

The vinyl sheet flooring used in the owner's bedroom is a new pattern developed by Armstrong Cork Company which incorporates gold and clear vinyl particles imbedded in a beige pattern. Although this is in the category of sophisticated flooring, it creates a beautiful, easily applied material. The family room, kitchen and utility room used the latest style of Tessara corlon vinyl sheet flooring with a color pattern utilizing five separate color chips. This flooring is an already well accepted product and is in large demand. Bedrooms #3 and the playroom utilize the new Centennial Excelon vinyl asbestos tile which is a spatter pattern. This material is easily laid over any type of surface and provides an easily cleaned, highly durable surface for an economic price. Vinyl asbestos tile is an excellent compromise between economy, function and beauty. The luxury vinyl sheet floorings are receiving excellent acceptance and add immeasurably to appeal and warmth.

LANDSCAPING

The landscaping plan was developed by students of the Landscape Architectural Department of Michigan State University. (See figure 39.) Better Homes and Gardens Magazine sponsored a competition among students in this course, and the two contest winners prepared the over-all plan for landscape development.

The entry walk, service patio, and living terrace were constructed in divided square pattern using redwood headers, and a broom textured concrete surface. Corrugated white Lucite acrylic panels were used to cover the entry walkway and service patio on a supported redwood egg crate framing.

A 16′ long 7′ high screen fence in front of the living terrace uses accent colored chipboard panels alternated with flat white acrylic sheets. The translucent plastice panels allow light into the terrace and accents the planting areas behind the fence.

Slopes with walks provide access to the raised rear yard area. A wooden playdeck will be added at the rear of the playroom as outlined in the general landscape theme.

INTERIOR DECORATING AND FURNISHING

The interior decorating and furnishing was designed by Better Homes and Gar-

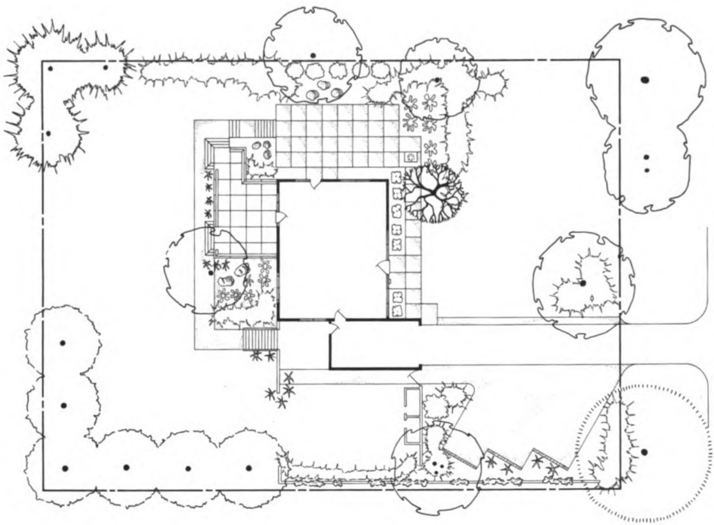


FIGURE 39 — *General landscape plan*

dens Magazine. Drapes and furniture were specified by them and provided by various manufacturers.

Vertical traversing Tontine plastic venetian blinds were used in the full height windows of the entry which provided a functional and attractive method of handling large expanses of glass. Fiberglas drapes and curtains were used throughout the house in a colorful and tasteful manner.

The furnishings, rugs and carpets provided a modern attractive decor. Color was generously used in the floor treatment and wood predominated in the furnishing.

PUBLIC EVALUATION

Upon completion of the Research House and after all decorating and furnishing was completed, builders and the general public were invited to visit and inspect the home. They were asked to write, on prepared sheets, what they liked or did not like. The following is a summary of these surveys. We asked: Would you like to have these features in your house?

FEATURES IN RESEARCH HOUSE	BUILDERS Yes	No	Undecided	GENERAL PUBLIC Yes	No	Undecided
	%	%	%	%	%	%
Over-all appearance	44	8	48	66	21	13
Floor Plan	74	13	13	75	14	11
Storage Space	83	10	7	90	5	5
Foam panel slab floor	38	24	38	53	12	35
Foam core panel on walls and roof	70	8	22	64	8	28
Brick facing	90	0	10	67	14	19
Roof coating	65	11	24	43	7	50
Exterior wall finish	64	7	29	51	16	33
Window design	59	12	39	55	30	15
Plastic front entrance sidelights	80	8	12	66	11	23
Garage door and hardware	36	50	14	29	31	40
Ceramic rubber in hall and bath floor	100	—	—	90	3	7
Hardwood strip flooring	73	11	16	71	13	16
Finish on ceiling in living room and family room	67	26	7	60	26	14
Stairway	66	10	24	70	19	11
Steel clad, foamed core front door	79	3	18	55	15	30
Passage door hardware	18	41	41	53	15	32
Closet door hardware	15	62	23	59	24	17
Luminous ceilings	89	8	3	81	11	8
Vinyl coated exposed ducts	67	14	19	62	10	28
Molded fiberglas shower stall	90	3	7	86	6	8
Tub-Shower Mixing Valves	93	0	7	80	3	17
Folding shower door	—	—	—	63	25	12
Built-in counter oven and range	—	—	—	68	14	18
Kitchen cabinets and hardware	48	21	31	76	14	10
Ventilating exhaust system	58	9	33	72	4	24
Baseboard electric outlet system	—	—	—	84	4	12
Hi-Fi Intercom System	96	0	4	75	14	11
Interior passage and closet doors	14	72	14	—	—	—
Molded fiberglas double bowl vanitory in hall bathroom	—	—	—	76	12	12
Sliding partition in hall bathroom	—	—	—	75	13	12
Acoustic tile in the front hall ceiling	—	—	—	80	4	11

PARTICIPATING MANUFACTURERS
OF NEW PRODUCTS IN THE
1959 NAHB-MSU RESEARCH HOUSE

ALUMINUM COMPANY OF AMERICA
1501 Alcoa Building, Pittsburgh 19, Pa.
(Mr. Thomas J. Lannen)
Aluminum jamb caps at surface mounted passage doors

B. & B. CHEMICAL COMPANY
784 Memorial Drive, Cambridge, Mass.
(Mr. Charles Fosgate, Jr.)
Sand textured, factory applied urethane roof coating
Field applied roof tape and sealer

CHALLENGER LOCK COMPANY
2349 West La Palma Ave., Anaheim, Calif.
(Mr. R. C. Cerf)
Entry door locksets with white Delrin plastic knobs

COLONIAL PLASTICS MANUFACTURING CO.
2685 E. 79th St., Cleveland 4, Ohio
(Mr. James Voelker)
Tuftite PVC waste pipe and PVC fittings
PVC effluent field pipe and fittings

COMPTON, INC.
P. O. Box 1946, Clarksburg, W. Virginia
(Mr. R. R. Ruehle)
Textured Hardkote gypsum drywall ceiling finish
Flat Hardkote gypsum drywall wall finish

COAST FOUNDRY AND MANUFACTURING CO.
2700 East First St., La Verne, Calif.
(Mr. W. L. Gefferey)
"Delrin" plastic water closet ballcocks

CURTIS COMPANIES, INC.
Clinton, Iowa
(Mr. Merle Baker)
Louvre ventilating units at west elevation
Combination wood sash door

THE DOW CHEMICAL COMPANY
Midland, Michigan
(Mr. Thomas Werkema)
Closed cell polystyrene core glass sidelight units
Rovana woven Dining Room wall fabric

E. I. DuPONT de NEMOURS AND CO., INC.
Wilmington 98, Delaware
(Mr. Arthur G. Webster)
Sand textured factory applied Hypalon exterior wall coating
Hypalon caulking
Neoprene waterproofing below grade
"Zytel" insulated electric cable

EMERSON PRYNE
8100 Florissant Ave., St. Louis 21, Mo.
(Mr. Donald Harper)
Dual room ventilating exhaust system, ducts, fans, and grilles

B. F. GOODRICH COMPANY
3135 Euclid Ave., Cleveland 15, Ohio
(Mr. Robert Holtz)
Hi-Temp Geon hot and cold water pipe and fittings
Vinyl stair hand rail cap

KEL-WIN MANUFACTURING COMPANY
3021 West Clay St., Richmond 30, Va.
(Mr. R. J. Keller III)
Lavatory faucets—"Delrin" valve assemblies

KOPPERS COMPANY, INC.
P. O. Box 65, Monaca, Pa.
(Mr. Philip Waugaman)
Dylite cement asbestos floor slab panels
Stabilized Dylite plywood exterior wall panels and roof panels
Gypsum board and plywood Dylite partition panels
Dylite factory brick finished exterior wall panels

MINNESOTA MINING AND MANUFACTURING CO.
900 Bush Ave., St. Paul 6, Minn.
(Mr. Paul Wilson)
Interior aluminum joint tape
Underlayment floor mastic
Wall paneling mastic

MOEN FAUCET
377 Woodland Ave., Elyria, Ohio
(Mr. Edward F. Brizz)
Shower-Tub single handle mixing valves

NATIONAL FIBERGLASS
P. O. Box 876, Gilroy, California
(Mr. William S. Rielly)
One-piece molded fiberglas double bowl vanitory
One-piece molded fiberglas shower stall and hood

NICKEY BROTHERS, INC.
2700 Summer Ave., Memphis, Tenn.
(Mr. R. W. Woods)
Oak and Apitong hardwood strip flooring and finish

NuTONE, INC.
Madison and Redbank Roads
Cincinnati 27, Ohio
(Mr. Charles Kenney)
Hi-Fi Stereo Intercom System

H. K. PORTER COMPANY, INC.
338 14th St., Ambridge, Pa.
(Mr. Robert Johnson)
Vinyl baseboard covered convenience outlet electric swstem

REYNOLDS METALS COMPANY
5th and Cary Sts., Richmond 10, Va.
(Mr. Eugene I. Deas)
Aluminum primed foil for wall and roof panels
Stair Baluster and handrail

STANLEY ELECTRIC TOOL COMPANY
STANLEY HARDWARE
480 Myrtle, New Britain, Conn.
(Mr. Kenneth Johnson)
Sill plate leveling machine
Surfaset interior passage door hardware
Surface mounted closet door hardware and trim
Surface mounted garage door hardware
Aluminum kitchen cabinet frame and hardware
Expandable closet pole

U. S. CERAMIC TILE
217 4th St., N.E., Canton 2, Ohio
(Mr. Harold R. Thomas)
Ceramaflex rubber imbedded ceramic tile mats

U. S. PLYWOOD CORPORATION
55 W. 44th St.,
New York 36, N. Y.
(Mr. Norbert Shumaker)
Interior plywood passage Door-Fin doors
Closet Novoply Doors
Lucite Patio roof covering

U. S. STEEL CORPORATION
525 William Penn Place
Pittsburgh 30, Pennsylvania
(Mr. Robert J. Ritchey)
Vinyl coated steel for exposed duct-light traffer
Vinyl coated steel clad foamed core exterior doors

WESTINGHOUSE ELECTRIC CORPORATION
246 E. 4th St., Mansfield, Ohio
Mr. Watty Slabaugh)
Built-in single unit range and oven with electric sub-panel

PARTICIPATING MANUFACTURERS OF PRODUCTS ON THE MARKET IN THE

1959 NAHB-MSU RESEARCH HOUSE

AMERICAN STEEL DOOR COMPANY
11148 Harper Ave., Detroit 10, Mich.
(Mr. Joseph Daiek)
Steel closet shelf apron-pole

ARMSTRONG CORK COMPANY
Lancaster, Pennsylvania
(Mr. Harry Jensen)
Vinyl Sheet flooring
Vinyl Asbestos tile
Acoustic Tile Ceilings

E. T. BARWICK MILLS, INC.
Old Peachtree Rd., Chamblee, Ga.
(Mr. John Hoff)
Family Room rugs

BAUMRITTER CORPORATION
145 E. 32nd St., New York, N. Y.
(Mr. Dan Brown)
Family Room furniture

BEMIS MANUFACTURING COMPANY
Sheboygan Falls, Wisconsin
(Mr. John C. Kaulk)
Toilet seat with "Zytel" nylon plastic hinges

BRIGGS MANUFACTURING COMPANY
6600 E. 15 Mile Rd., Warren, Mich.
(Mr. F. O. Cole, Jr.)
Plumbing fixtures

BRYANT MANUFACTURING COMPANY
2020 Montcalm St., Indianapolis 7, Ind.
(Mr. Keith Davis)
Furnace, cooling coil, and condenser

CARLTON MANUFACTURING COMPANY
Carrollton, Ohio
(Mr. S. W. Osterhout)
"Monoflash" Neoprene vent pipe flashing

CHAR-GALE MANUFACTURING COMPANY
4325 Hiawatha, Anoka, Minnesota
(Mr. N. J. Dovolis)
Aluminum heat registers

E. I. DuPONT deNEMOURS COMPANY, INC.
Wilmington 98, Delaware
(Mr. Arthur G. Webster)
Exterior Lucite acrylic paint
Reinforced acrylic Lucite patio covering
Fabrolite vinyl wall covering
Super Plastic Urethane Floor Varnish
Hypalon concrete floor paint

FIBERESIN PLASTIC COMPANY
Oconomowoc, Wisconsin
(Mr. John Daggett)
Fiberesin counter and vanity tops, cabinet doors and drawer fronts

FILON PLASTICS CORPORATION
127 Lomita St., El Segundo, Calif.
(Mr. Robert A. Lieban)
Shoji sliding door

GENERAL ALUMINUM PRODUCTS
817 Hall St., Eaton Rapids, Mich.
(Mr. Richard Trumley)
Combination aluminum storm door

GENERAL MARKET
1452 East Michigan, Lansing, Mich.
(Mr. Charles Bragg)
Water softener unit

HAYS MANUFACTURING COMPANY
801 West 12th St., Erie, Pa.
(Mr. L. L. Buzzard)
Water flow control valves

BERT R. HUNCILMAN AND SON
New Albany, Indiana
(Mr. Lynn Huncilman)
Furnace flue and roof housing

JO-LI-ET GUTTER GARD, INC.
Glenbrook, Connecticut
(Mr. Joseph LiVolsi)
Gutter guards

KIRSCH COMPANY
309 Prospect, Sturgis, Mich.
(Mr. Arthur Evers)
Drapery track and hardware

KOPPERS COMPANY, INC.
P. O. Box 65, Monaca, Pa.
(Mr. Philip Waugaman)
Treated sill plates
Polyethylene membrane
Plywood underlayment

KROEHLER MANUFACTURING COMPANY
Naperville, Illinois
(Mr. Larry Keller)
Living Room furniture

F. H. LAWSON
Cincinnati 4, Ohio
(Mr. L. F. Wilmhoff)
Medicine Cabinets

MAGEE CARPET COMPANY
Bloomsburg, Pennsylvania
(Mr. Richard Kressler)
Living Room carpet

MICHIGAN BELL TELEPHONE COMPANY
20010 Jas Conzens Hwy., Detroit 35, Mich.
(Mr. P. G. Leslie)
Pre-wired telephone jacks

NATIONAL ALUMINUM COMPANY
1133 Alum Creek Drive, Columbus 9, Ohio
(Mr. Clarence L. Parson)
Vinyl, aluminum frame tub enclosure

NuTONE, INCORPORATED
Madison and Redbank Roads
Cincinnati 27, Ohio
(Mr. Charles Kenney)
Door buttons and chimes
Kitchen Center
Bathroom scale

OWENS-CORNING FIBERGLAS CORPORATION
717 5th Ave., New York 22, N. Y.
(Miss Rutn D. Sunley)
Drapes

PERMACEL
New Brunswick, New Jersey
(Mr. F. W. Bartle)
"Teflon" pipe dope tape

PITTSBURGH PLATE GLASS
One Gateway Center, Pittsburgh 22, Pa.
(Mr. Kelly Dyer)
Twindow Glass units
Graylite heat absorbing glass

REMINGTON ARMS COMPANY, INCORPORATED, Bridgeport 2, Connecticut
(Mr. F. A. McGregor)
Sill plate anchor studs and gun

REYNOLDS METALS COMPANY
5th and Cary Sts., Richmond 10, Va.
(Mr. Eugene I. Deas)
Aluminum shear plates, nails and flashing
Aluminum gutters and downspouts

RUBATEX, Division of
Great American Industries, Inc.
Railroad Avenue, Bedford, Virginia
(Mr. W. C. Walters)
Neoprene sponge washers for patio roof covering connections

RUSSELL REINFORCED PLASTICS COMPANY, 521 W. Hoffman Avenue
Lindenhurst, New York
(Mr. E. C. Schultz)
Reinforced acrylic "Lucite" luminous ceilings
Decorative "Lucite" fence panels

RUUD MANUFACTURING COMPANY
Second National Bank Building
Connellsville, Pennsylvania
(Mr. Malcolm M. Scott)
Hot water heater
Duo-Temp control unit

SARGENT AND COMPANY
100 Water St., New Haven 9, Conn.
(Mr. Walter Scott)
Exterior door locksets with Delrin knobs

SHOWERFOLD DOOR CORPORATION
6585 West Warner St., Detroit 10, Mich.
(Mr. Sol M. Collins)
Polyethylene Alathon folding shower door

STANLEY BUILDING SPECIALTIES, INC.
105 Sycamore Rd., Severna Park, Md.
(Mr. Gerard X. Rioux, Jr.)
Jalousie ventilating units

STRUCTURAL PRODUCTS, INCORPORATED
Charlotte, Michigan
(Mr. K. A. Zick)
Family Room shelving

TIMBER ENGINEERING COMPANY
1319 18th Street, N.W.
Washington 6, D. C.
(Mr. David Norcross)
Shear plates
Joist hangers

THOMAS INDUSTRIES, INC.
(Moe Light Division)
410 So. 3rd, Louisville, Kentucky
Lighting fixtures

VERTICAL BLINDS CORPORATION OF AMERICA, 1936 Pontius Avenue
Los Angeles 25, California
(Mr. R. J. Cayton)
Tontine vertical entry blinds

WASHINGTON STEEL PRODUCTS, INC.
1940 East 11th St., Tacoma 2, Wash.
(Mr. Lowell O'Conner)
Plastic drawers and hardware

WEBB INDUSTRIES, INCORPORATED
Lake Road, Bay Village, Ohio
(Mr. E. C. Webb)
"Zytel" nylon shower heads

WESTINGHOUSE ELECTRIC CORPORATION
246 E. 4th Street, Mansfield, Ohio
(Mr. W. E. Slabaugh)
Appliance Center
Dishwasher
Garbage disposer
Refrigerator-Freezer
Clothes washer and dryer

YEOMANS BROTHERS CO.
1999-2 N. Ruby St., Melrose Park, Ill.
Cavitet sewage disposal unit

ZYLOS RUBBER COMPANY
(Division of Firestone Tire and Rubber)
Akron 1, Ohio
(Mr. Carl Shaffer)
Hardwood flooring mastic